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7. Abstract

The subject report provides an assessment of process and facility options for treating Hanford Site tank waste for immobilization and final disposal. Currently known options for treatment and immobilization of double-shell tank (DST) wastes, new and existing facilities for performing the processing operations, and the timing and capacity of needed feed pretreatment facilities are evaluated. The lower cost processing and facility options that are of reasonable technical certainty are identified. A preferred option is identified that can result in a potential waste disposal program savings of $500 million. The preferred option involves water washing of neutralized current acid waste (NCAW) sludge in a DST or in the 244-AR vault (rather than in B Plant), and accelerating implementation of the transuranic extraction (TRUEX) process at B Plant for treatment of follow-on DST wastes. Increasing the vitrification capacity for DST wastes from 45 kg/h to 100 kg/h is also recommended for the preferred option.

Major issues pertaining to both waste processing and facility options, and appropriate development requirements to resolve these issues are identified.

This report provides information that was developed and presented in draft form in fiscal year (FY) 1988. Several follow-on studies have since been performed that addressed key items and recommendations made in this report. The report "Assessment of Double-Shell Tank Waste Pretreatment Options," WHC-SP-0464 (March 1989) summarizes this information. The conclusions and recommendations in WHC-SP-0464 support the majority of those presented in this report. Consequently, this report has not been updated to incorporate any changes to major assumptions, e.g., those associated with operational schedules, milestones, and costs. Issuance of this report in final form provides detailed background information and bases that support the more recent studies.

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PROCESS AND FACILITY OPTIONS FOR PRETREATMENT OF HANFORD SITE TANK WASTES

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PREFACE

This report provides information that was developed and presented in draft form in FY 1988. Several follow-on studies have since been performed which addressed key items and recommendations made in this report. The report "Assessment of Double-Shell Tank Waste Pretreatment Options," WHC-SP-0464 (March 1989) summarizes this information. The conclusions and recommendations in WHC-SP-0464 support the majority of those presented in this report. Consequently, this report has not been updated to incorporate any changes to major assumptions, e.g., those associated with operational schedules, milestones, and costs. Issuance of this report in final form provides detailed background information and bases that support the more recent studies.

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PROCESS AND FACILITY OPTIONS FOR PRETREATMENT OF HANFORD TANK WASTE

1.0 INTRODUCTION

An engineering study was performed in 1983 to define and evaluate options for preparing existing and future Hanford Site double-shell tank (DST) wastes for final disposal operations (Schulz, Sloughter, Kupfer 1983). The study determined preferred waste treatment processes and facilities. Three preferred flowsheets for preparing feeds to immobilization facilities from candidate DST wastes were derived by applying screening criteria to 80 processing options. The study cited significant economic and technological advantages for upgrading the existing B Plant facility to start the feed pretreatment operations as quickly as possible. The study also favored early startup of a facility to begin immobilization and near-surface disposal of low-level waste (LLW), and early startup of a facility to vitrify high-level waste (HLW) for disposal in a HLW repository.

Since the 1983 study, additional technological information, including the following, has been generated that can influence the plans for treatment and disposal of Hanford Site tank wastes.

- Characteristics of existing wastes and updated projections of future waste quantities and compositions have been obtained.

- Development of new process technologies for reducing the volume of waste feed to a vitrification process by removing transuranic (TRU) components from the waste using the transuranic extraction (TRUEX) process has progressed.

Certain other important events have also occurred or are in progress:

- The U.S. Department of Energy (DOE) has decided to suspend operations of the N Reactor indefinitely, and to place it in cold standby.

- The Final Environmental Impact Statement for Disposal of Hanford Defense High-Level, Transuranic, and Tank Waste (HDW-EIS) (DOE 1987) and the Record of Decision have been issued. These documents identify the preferred alternative as grouting LLW and vitrification of the high-level and TRU fractions. They also state that an assessment of the need for retrieval, processing, and disposal of single-shell tank (SST) wastes is required and that the Hanford Waste Vitrification Plant (HWVP) provide capability for increasing vitrification capacity in the event that processing of SST wastes is required.

- Design and development of the HWVP is underway. The HWVP is expected to begin operations in 1999 and potentially as early as 1996, if pretreatment activities can be accelerated.

- Construction of a Grout Treatment Facility (GTF) for converting LLW to a cementitious solid that will be disposed of in near-surface vaults was completed in FY 1988. Grouting operations with actual LLW began in August 1988.

- Upgrades to B Plant are underway to implement a sludge washing and solid-liquid separation process and ^{137}Cs removal process to reduce the amount of neutralized current acid waste (NCAW) sludge fed to the HWVP. A demonstration for pretreatment of NCAW is scheduled in FY 1993, and full scale operations are expected to be underway at B Plant in FY 1994.

- Evolving changes to orders and regulations create potential impacts on requirements for upgrading and operating existing processing facilities. These regulations create uncertainties in the ability to extend the B Plant pretreatment mission to other DST wastes [i.e., Plutonium Finishing Plant (PFP) sludges, neutralized cladding removal waste (NCRW), and complexant concentrate (CC)] and SST wastes.

The current Hanford Waste Management Plan (HWMP) (DOE-RL 1987a) provides a preferred plan for treatment and disposal of Hanford Site wastes. Much of the new information that has been acquired since the 1983 engineering study (Schulz, Sloughter, Kupfer 1983) has been used to develop this plan. The Hanford Waste Management Technology Plan (HWMTP) (DOE-RL 1987b) identifies the necessary technology development required to implement the waste disposal alternatives presented in the HWMP. These plans and the recent events and progress on waste management activities are reflected in this study. The current planning baseline described in the HWMP and HWMTP for pretreatment of Hanford Site DST waste is as follows.

- Pretreatment processing of DST wastes will be performed in the B Plant Facility.

- NCAW sludge will be washed in B Plant, and the washed sludge will be vitrified at the HWVP. The supernatant will undergo radiocesium removal followed by grouting for disposal as LLW in near-surface engineered vaults.

- Wastes in other DSTs (i.e., PFP sludge, NCRW, and CC) will be treated in B Plant using the TRUEX process to remove the TRU components. The TRU fraction and HLW fraction will be vitrified at the HWVP and will be disposed of in a geologic repository. The LLW fraction will be incorporated into grout for disposal in near-surface engineered vaults.

This report provides a reassessment of process and facility options for treating Hanford Site tank wastes for immobilization and final disposal. The reassessment is made in light of the recent technological developments and events listed above. Currently known process options for treatment and immobilization of DST and SST wastes, new and existing facilities for performing the processing operations, and the timing and capacity of needed feed pretreatment facilities are evaluated. The processing and facility options that are of reasonable cost and technical certainty are identified, and a preferred waste treatment and facility option is recommended. Major issues pertaining to both waste processing and facility options are identified, and appropriate development requirements to help resolve these issues are defined.

2.0 SUMMARY AND RECOMMENDATIONS

The reassessment of the DST waste pretreatment process and facility options is summarized in this section. A preferred waste pretreatment option is presented and recommendations to confirm the technical basis for the preferred option are provided.

2.1 SUMMARY

This report provides an assessment of process and facility options for treating Hanford Site tank wastes for immobilization and final disposal. This assessment is an update of an earlier study by Schulz, Sloughter, and Kupfer 1983. The report evaluates various pretreatment process and facility alternatives for DST and SST wastes. The Hanford Site DST wastes included in the scope of this study are as follows:

- DST Wastes
  - Neutralized Current Acid Waste (NCAW)
  - Complexant Concentrate (CC)
  - Plutonium Finishing Plant (PFP) Sludges
  - Transuranic Neutralized Cladding Removal Waste (NCRW).

The impact of a decision to retrieve and process SST wastes on the DST waste pretreatment program is also addressed.

Two processing alternatives are considered for the wastes:

- Separation of solids or sludges from supernatant liquids and washing of solids with water to remove soluble salts

- Solid-liquid separations and reduction of the volume of waste requiring vitrification by dissolving the sludges and removing TRU components from the acidic waste solutions using the TRUEX process.

This study examines a range of pretreatment process options available from sludge washing all DST wastes to TRUEX processing all DST wastes. Intermediate process options evaluated are sludge washing of NCAW or PFP solids only and TRUEX processing of the remaining three waste types.

In addition, complexant destruction of CC supernatant and removal of ^{137}Cs from NCAW supernatant are assumed to be required for both the solids washing and TRUEX alternatives. Removal of ^{90}Sr from TRUEX process raffinate is also required for alternatives that utilize the TRUEX process for NCAW pretreatment.

Four facility options are identified as possible locations where TRUEX process pretreatment operations could be performed:

- B Plant
- PUREX Facility
- A new stand-alone facility
- An expanded HWVP facility.

Two facility options are identified as possible locations where solids washing operations could be performed:

- B Plant
- In double-shell tanks.

The current baseline plan in the Hanford Waste Management Plan for treatment of DST waste shows: (a) NCAW sludge solids will be washed in B Plant; (b) the TRUEX process will be applied to the other candidate DST wastes at B Plant; (c) the TRU and HLW fractions of the DST waste will be vitrified at the HWVP using a melter with a throughput capacity of 45 kg glass per hour; (d) the vitrified wastes will be disposed of in a HLW repository; and (e) the LLW will be immobilized in grout and disposed of in near-surface engineered vaults. The approximate total cost for completion of the baseline mission is $3.4 billion. This report reassesses the current baseline plan and provides the basis for confirming or recommending changes to the present plan.

The results of this study indicate a significant reduction of total DST waste treatment and disposal mission costs (from the current baseline plan) can potentially be achieved. The costs can be reduced by:

- Increasing the HWVP vitrification capacity
- Providing TRUEX process capacity to support the vitrification capacity
- Using double-shell tanks instead of B Plant for washing NCAW sludge solids
- Implementing the TRUEX process on an accelerated basis in B Plant for treatment of the remaining DST wastes.

A marked reduction in waste pretreatment and vitrification operation costs result if the HWVP vitrifies all waste using a 100 kg/h melter rather than a 45 kg/h melter, and the throughput of the TRUEX process pretreatment facility is sized to support operation of the large capacity melter. The HWVP facility is designed to accommodate the 100 kg/h melter when required. Present plans call for initial operations with a 45 kg/h melter. Processing

all candidate DST wastes with the 100 kg/h melter and higher throughput TRUEX process equipment reduces mission costs up to $250 million compared to utilization of the 45 kg/h melter in the baseline plan.

This study also identifies an alternate NCAW sludge washing scenario that has additional mission cost savings of $250 million. In the alternate NCAW sludge washing scenario, NCAW sludge is washed in a DST in lieu of washing NCAW in B Plant. The TRUEX process is applied to the remaining DST waste in B Plant. Because of the recent decision to place N Reactor in cold standby, the last irradiation of N Reactor fuel was in late 1986 and the resulting NCAW will be approximately 10-yr aged waste in the mid 1990s. Aged NCAW and lower decay heat in the sludge may allow the use of existing DSTs for settle-decant washing of NCAW sludge instead of the small 19,000 L (5,000 gal) B Plant tanks originally specified for higher heat content NCAW. The operational times and expenditures required for in-tank washing of NCAW sludge are significantly less than washing NCAW in small volume B Plant tanks. In-tank washing of NCAW sludge enables continuous HWVP operations by providing feedstock to HWVP while other DST wastes are being treated at B Plant. The B Plant facility would continue to provide ^{137}Cs removal from NCAW supernatant. The combination of in-tank NCAW sludge washing with the action of increasing HWVP vitrification and B Plant TRUEX processing capacity eliminates HWVP standby time and minimizes operational costs. Washing NCAW sludge in a DST instead of B Plant requires a three year acceleration of the TRUEX process installation in B Plant (1994 line item) to maximize cost savings. An engineering analyses is required to confirm the feasibility of washing NCAW in a DST.

The potential cost reduction over the current baseline case for incorporating the facility optimization actions described above is summarized in Table 2-1. The potential total cost reduction is approximately $500 million from the $3.4 billion baseline case.

Table 2-1. Preferred Pretreatment Option - Potential Cost Reduction.

Action	Cost reduction[a] millions of FY1988 dollars
1. Increase TRUEX and vitrification capacity	250
2. Sludge wash NCAW in DST	250
Total	500

[a] From baseline cost of $3,400 million.

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The study indicates small cost increases, up to $100 million, for using alternate facilities instead of B Plant for pretreating DST wastes using the TRUEX process. The cost for using an expanded HWVP is approximately the same as for using B Plant, provided a commitment is made prior to freezing the HWVP design (March 1989). The expanded HWVP would require an increase in the HWVP project cost and schedule. The probability of this decision being made within 6 mo of issuance of this report with no net cost incentive is low. The use of the existing PUREX facility following completion of reprocessing the existing N Reactor fuel inventory is projected to increase total program costs by $50 million. The availability of the PUREX facility for pretreatment processing is contingent upon changing the N Reactor cold standby status to a shutdown status. The use of a new stand-alone facility increases total program costs by approximately $100 million over B Plant costs. A new stand-alone facility could not be in operation before FY 2001 (with a 1994 line item). A loss in continuity of HWVP operations would result with a delay in completion of the vitrification operation by approximately 2 yr. Both the PUREX and new stand-alone facility options require a decision by October 1990 for a 1994 line item or the projected costs will increase even further.

A summary of canisters of glass, operating times, and total costs for the treatment of DST wastes at the B Plant facility for the range of process options evaluated in this report is provided in Table 2-2. The two lowest cost alternatives, "Sludge Wash PFP in a DST and TRUEX Remainder" and "TRUEX all DST Waste," assume that the TRUEX process will be used for NCAW sludge. Use of the TRUEX process for NCAW sludge requires development of technology by October 1990 for removal of ^{90}Sr from acidic TRUEX raffinate to meet current grout disposal requirements. A strontium removal technology development program is not currently scheduled and the probability of having the technology basis available within 2 yr is low. The preferred option identified in this report (i.e., "Sludge Wash NCAW in a DST and TRUEX Remainder") is the lowest cost process alternative that does not require strontium removal from acidic TRUEX process raffinate.

Table 2-2. Double-Shell Tank Waste Pretreatment B Plant Process Alternates.

Process scenario	Canisters of glass	Operating time (yr)		Total cost, millions of FY 1988 dollars	
		B Plant	HWVP	HLW disposal	HLW and WIPP disposal[a]
Baseline 45 kg/h melter					
Sludge wash NCAW in B Plant; TRUEX remainder	1,560	14.5	14	3,400	3,250
Increased dissolver capacity, 100 kg/h melter					
Sludge wash NCAW in B Plant; Sludge wash PFP and NCRW in DST; Complexant destruction of CC in B Plant	3,350	12	11	3,800	3,200
Sludge wash all waste in DST[b]	3,350	-	11	3,400	2,800
Sludge wash NCAW in B Plant; TRUEX remainder	1,560	10.5	8	3,150	3,000
Sludge wash NCAW in DST; TRUEX remainder[c]	1,560	6	5	2,900	2,750
Sludge wash PFP in DST; TRUEX remainder	1,500	6	5	2,850	2,600
TRUEX all waste	1,200	7	4	2,750	2,600

[a]Vitrified NCRW and PFP waste disposed at the WIPP.
[b]Assumes complexant destruction of CC is done in DST.
[c]Preferred option.

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Table 2-2 also identifies the potential cost reduction for disposal of TRU classification wastes at the Waste Isolation Pilot Plant (WIPP) rather than a high-level waste repository. The cost of transportation and disposal of waste canisters of glass in the WIPP is significantly less than disposal of canisters in a high-level repository. The potential cost reduction for disposal of candidate TRU wastes (PFP wastes and NCRW) at the WIPP rather than a HLW repository is $150 to 600 million for the process alternatives shown in Table 2-2. The potential cost reduction of WIPP disposal for the preferred option identified by this report is $150 million. The WIPP disposal option should be actively pursued for the candidate wastes most likely to gain acceptance at the WIPP as TRU waste; (i.e., PFP wastes and NCRW).

Several regulatory issues which have potential significant impacts on both process and facility options have been identified.

- NRC Concurrence that Grout is LLW--The Nuclear Regulatory Commission (NRC) is concerned that some of the DST waste planned for disposal in near surface grout vaults could be high-level wastes as defined by 10 CFR 60 and would therefore have to be licensed by the NRC for disposal. To attain NRC concurrence that grout disposed near-surface is not HLW, (i.e., it is LLW), it may be desirable to reduce the concentrations of radionuclides in grouts to significantly lower levels than those defined by the current grout criteria. Radionuclide concentrations in the grout meet Class C LLW levels (10 CFR 61); however, preparation of grouts with radionuclide contents comparable to Class A LLW levels may be deemed desirable. The primary radionuclides considered for additional removal are ^{90}Sr, ^{137}Cs, and the TRU components. A significant development program and major pretreatment process changes will be required to reduce radionuclide contents of waste supernatants to grout by a factor of 10 or more. Because of the significant impact that reduction of grout radionuclide

concentrations to levels comparable to 10 CFR 61 Class A LLW could have on the DST pretreatment program, early identification of available options and the effects on cost and schedule should be determined.

- B Plant Regulatory Compliance--The Department of Energy (DOE) Order 6430.1A identifies criteria for new facilities or additions to existing facilities. Compliance to the 6430.1A criteria is voluntary for existing facilities and DOE-RL determines the degree of compliance required for operating the existing B Plant facility. The current B Plant safety analysis concludes that no credible accident would result in exceeding the offsite release limits. This study determined that B Plant upgrades to attain full DOE Order 6430.1A compliance could require approximately $160 million capital and result in a construction outage of 3 to 5 yr. The total capital and operating program cost would increase approximately $400 million for a full 6430.1A compliance B Plant upgrade. Lower cost compliance options are a FY 1994 line item for a new standalone facility or an expanded HWVP. Delay of the expanded HWVP decision beyond 1989 would result in increased costs. In-tank washing NCAW sludge and use of a new standalone facility for pretreating the remaining wastes using the TRUEX process would increase total program costs $100 to 150 million over the preferred option. Imposing DOE Order 6430.1A compliance on B Plant for the 6 yr of operation required for the preferred option will delay the completion of the vitrification program and has significant cost impact.*

*An assessment of the viability of B Plant to perform the waste management mission was summarized in WHC 1989, subsequent to preparation of this report. The areas investigated included (1) an evaluation of compliance with DOE, Washington State, and federal regulations; (2) a preliminary accident analysis; (3) a natural forces evaluation to determine the facility structural response to a seismic event; and (4) a life-extension analysis to examine the facility for aging effects. No issues were found that would permit B Plant from completing the pretreatment mission. The viability evaluations identified an additional $14 million in upgrades required to bring the facility to a condition that complies with DOE design criteria, safety, and environmental orders.

- Retrieval of Single Shell Tank Wastes--If a future decision is made to retrieve and process SST wastes for geologic disposal, the ability to extend the DST pretreatment mission in existing facilities (i.e., B Plant) to SST wastes is a major issue. Retrieval of all 149 SSTs would require extending the B Plant operations from 6 yr DST waste processing to a minimum of 30 yr (DST waste plus SST waste processing). The ability to operate a production facility for 30 yr without approaching full 6430.1A compliance is deemed unlikely. The decision to retrieve a significant portion of the Hanford SST wastes would result in recommending construction of a new stand-alone pretreatment facility as being more cost effective than upgrading B Plant to full 6430.1A compliance. If a decision is made prior to 1994 to retrieve SST wastes, cost savings may be realized by accelerating startup of the new standalone facility and processing a portion of the DST wastes in the new facility rather than in B Plant.

Several key technical issues which have a large and important bearing on both waste process and facility options have been identified. These issues generally relate to the need for characterization of the candidate waste feeds and for pretreatment process development efforts.

- Can the TRUEX process be successfully applied to Hanford DST and SST waste?

  An enhanced development program is needed to verify the capability of the TRUEX process to remove TRU components from candidate waste solutions to <100 nCi/g. Adequate flowsheets must be developed to define operating parameters and support design efforts.

- How much sludge will dissolve and what is the impact on vitrification and grout waste forms?

  Variations from the sludge dissolution assumptions used in this study will directly affect the number of canisters of glass that

would be generated. Pretreatment facility equipment sizing and processing throughputs would be directly affected. The disposal costs for each waste type would also be affected which could in turn affect the preferred pretreatment process and facility option. Laboratory-scale tests need to be performed as soon as possible using representative waste samples to obtain dissolution data and optimize dissolution parameters.

- What is the effect of waste treatment on Waste Form Qualification?

  As part of the Waste Form Qualification (WFQ) effort, development of laboratory and bench-scale testing must be performed as soon as possible to address the impacts of application of the TRUEX process on PFP, CC and NCRW waste feeds to the vitrification process.

- Can the NCAW sludge be successfully washed in a DST?

  The proposed washing of NCAW sludge in existing DSTs requires a technical analysis to assure that there are no safety issues as a result of excessive temperatures in the settled sludge. The current programs for waste retrieval and solids washing need to be reviewed and modified if necessary to support NCAW washing in a DST. The impact of washing NCAW sludge in a DST on waste volume projection and tank space availability in the 1990s needs to be determined.

- What is the effect of a decision to reduce radionuclide concentrations in the grout feed?

  The processes proposed for the current baseline plan or the preferred option do not currently produce grout feed with radionuclide concentrations comparable to Class A LLW (10 CFR 61) limits. Reducing radionuclide concentrations would likely require extensive pretreatment process and facility changes. An engineering study to evaluate process and facility options and definition of development requirements to produce lower radionuclide

concentrations in the grout feed from the pretreatment process is required. An initial assessment of a decision to reduce radionuclide concentration in grout indicates that use of existing Savannah River Plant (SRP) technology and sludge washing may be required and could increase DST waste disposal program costs by approximately $600 million.

In summary, this reassessment of DST waste pretreatment process and facility options concludes that:

- The process of washing NCAW sludge and application of the TRUEX process for PFP, CC and NCRW remains the most cost effective process with the least technical risk

- Facility utilization can be optimized to significantly reduce DST waste treatment and disposal costs, with a potential of up to $500 million in cost reductions from the current baseline plan

- The planned B Plant NCAW sludge washing demonstration supports both the current baseline plan and the preferred option. Near-term B Plant program costs and schedules through FY 1993 would not be affected.

2.2 RECOMMENDATIONS

It is recommended that the following actions be taken, by October 1990, to confirm the technical basis for the "Preferred Option:"

- Maintain the current B Plant program to demonstrate washing of NCAW sludge

- Plan for installation of a 100 kg/h melter at HWVP startup, and maximize TRUEX process capacity at B Plant to the extent possible

- Perform work necessary to resolve by October 1990 the decisions for washing NCAW in-tank and committing to a 1994 TRUEX line item

- Perform laboratory studies and engineering analyses to evaluate the programmatic impact of reducing the radionuclide concentrations in LLW grout.

A decision analysis approach was utilized in this report which graphically depicts on a time scale the technical and programmatic decisions required to arrive at a viable DST pretreatment system. The alternate paths through the logic tree result in the process and facility options described in this report. The logic tree identifies the technology required to arrive at the preferred pretreatment option and also identifies the backup options. Following are the necessary supporting engineering and development efforts that must be pursued in FY 1989 and FY 1990 to resolve the decision points and confirm the preferred option.

- Accelerate characterization of candidate wastes to the pretreatment processes--particularly PFP and CC wastes.

- Initiate development of technology for dissolution of waste sludges. Begin development of TRUEX process flowsheets.

- Begin development of methodology for destroying complexants in acidic TRUEX process raffinate.

- Develop a preliminary approach for removal of selected key radionuclides from grout feed.

- Perform an engineering study to define the impact on the pretreatment and vitrification program of a decision to reduce radionuclide concentrations in grout.

- Develop plans for obtaining 400 kg samples of acid washed PFP, CC, and NCRW solids in B Plant by 1996 in support of the HWVP WFQ effort.

- Perform preconceptual design of the increased capacity TRUEX process in B Plant as a 1994 line item.

- Support DOE in definition of B Plant DOE Order 6430.1A compliance levels.

- Evaluate by March 1989 the impact on the HWVP project of increasing the melter throughput from 45 kg/h to 100 kg/h.

- Evaluate the heat transfer and safety aspects of washing NCAW sludge in a DST.

- Evaluate the implications of in-tank NCAW sludge washing on waste retrieval requirements, and on tank farm space requirements and availability.

- Begin efforts to determine acceptability of PFP and NCRW waste forms at the WIPP.

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3.0 WASTE DESCRIPTION

Preliminary process flow sheets have been developed for the major processing options for each type of defense waste stored in underground tanks (Appendix A). The waste compositions used to develop these flowsheets are given in this section. Waste types evaluated include NCAW, PFP waste, CC, NCRW, and SST sludge and salt cake. A brief description and volume of each waste type is given in Table 3-1.

Table 3-1. Volume and Description of Waste Types.*

Waste type	Volume m^3	Description
NCAW	7,040 m^3 (1,860 kgal) sludge and supernatant	Neutralized current acid waste generated by the co-decontamination cycle of the PUREX process (includes sludge and supernatant based on 926 L/MTU-7,607 MTU total)
PFP	1,460 m^3 (387 kgal) sludge	Solids stored in tank 102-SY in the 200 West area from Plutonium Finishing Plant, T Plant, and S Plant operations (includes sludge only, no supernatant)
NCRW	3,010 m^3 (796 kgal) sludge	Neutralized cladding removal waste generated from dissolution of Zircaloy-cladding from N Reactor fuel. Assumes TRU waste generation will be eliminated by the end of FY 1989
CC	16,100 m^3 (4,270 kgal) supernatant and sludge	Complexant concentrate greater than 10 g/L of organic complexants. Excludes any future salt well liquid that may be complexed in SSTs
SST waste	45,700 m^3 sludge 92,400 m^3 salt cake	Single-shell tank waste of which none, some, or all of total volume may be retrieved for pretreatment and disposal

*Recent information (Riley et al. 1988a) projects a slight reduction in volume and slightly different compositions for some waste types. Because these new projections will change glass volumes and grout volume projections only slightly, they do not impact the results or conclusions in this report.

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3.1 NEUTRALIZED CURRENT ACID WASTE

Neutralized current acid waste is generated by the addition of NaOH to the aqueous raffinate from the decontamination cycle of the PUREX Plant. After neutralization, the NCAW is stored in aging waste tanks TK 101-AZ and TK 102-AZ.

Gibson and Landeene (1987) provide an analysis from a blend of TK 101-AZ samples. The analyses are based on 20 vol% of settled solids. The NCAW composition is given in Table 3-2. With N Reactor placed in safe standby status, the total volume of NCAW is significantly reduced from previous projections. Ludowise (1988) estimates that 7,607 Metric Tons Uranium (MTU) of fuel will be processed in PUREX. This projection includes 1,377 equivalent MTU of Fast Flux Test Facility (FFTF) fuel and 51 MTU of pressurized water reactor (PWR) fuel processed in FY 1993. At 926 L of concentrated waste per MTU (245 gal/MTU) (Riley 1988b), 7,040 m^3 (1.86×10^6 gal) of NCAW will be generated.

3.2 PLUTONIUM FINISHING PLANT SLUDGE

Plutonium Finishing Plant sludge is stored in Tank 102-SY in the 200 West Area. Other contributing sources of Tank 102-SY are from operations of T Plant and S Plant. After wastes are deposited in the tank, the supernatant is decanted and transferred to 200 East Area where it is concentrated to double-shell-slurry feed. The remaining sludge and a small portion of the supernatant are accumulated in the tank for future treatment and disposal. The compositions of the combined sludge and supernatant and the distribution of each of the elements with the decanted supernatant, the sludge, and the supernatant remaining after decant are given in Table 3-3.

Table 3-2. Composition of Neutralized Current Acid Waste.[a]

Component	Concentration (g-mol/L)
OH^-	1.57
F^-	0.136
NO_2	0.675
NO_3	2.67
SO_4^{2}	0.235
CO_3^{3}	0.361
Na^+	7.85
AlO_2	0.785
Cr^{+3}	0.019
Fe^{+3}	0.104
Zr^{+4}	0.069
K^+	0.188
Component	**Concentration (g/L)**
U	1.45
TOC[b]	2.67
^{239}Pu	0.0041
^{241}Am	0.0040
^{237}Np	0.0180
Component	**Concentration (Ci/L)**
^{90}Sr-^{90}Y	3.66
^{137}Cs-^{137}Ba	3.11
^{106}Ru-^{106}Rh	0.078
^{144}Ce-^{144}Pr	0.274

[a]Gibson and Landeene, 1987, based on 926 L of concentrated waste/MTU.
[b]Total Organic Carbon.

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Table 3-3. Compositions and Volumes of Plutonium Finishing Plant Waste.

Component (g-mol/L)	Combined sludge and supernatant	Decanted supernatant	Sludge	Remaining supernatant
OH-	1.105	1.111	1.028	1.105
Na^+	1.900	1.910	1.768	1.900
AlO_2^-	0.189	0.179	0.323	0.189
SO_4^-	0.100	0.100	0.093	0.100
F-	0.099	0.100	0.092	0.099
$Ca(OH)_2$	0.008	0.000	0.109	0.008
$Mg(OH)_2$	0.010	0.000	0.141	0.010
$Fe(OH)_3$	0.012	0.000	0.173	0.012
$Mn(OH)_2$	0.003	0.000	0.049	0.003
Cr (soluble)	0.041	0.000	0.590	0.041
NO_3^- & NO_2^-	0.684	0.688	0.637	0.684
Component (g/L)	Combined sludge and supernatant	Decanted supernatant	Sludge	Remaining supernatant
U	4.80 E-04	0.000	0.007	4.80 E-04
Pu	4.90 E-03	0.000	0.070	4.90 E-03
Am	4.20 E-04	0.000	0.006	4.20 E-04
Component (Ci/L)	Combined sludge and supernatant	Decanted supernatant	Sludge	Remaining supernatant
^{90}SrY	0.004	0.000	0.005	0.004
$^{137}CsBa$	0.003	0.003	0.002	0.003
Stream vol (m^3)	21,400	19,580	1,460	380

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The composition of PFP sludges is based on the 488 m^3 (129,000 gal) of sludge that existed in the tank prior to 1987 and the projections of 975 m^3 (258,000 gal) of sludge for 1987 and beyond. Bratzel (1985) reports the analytical results of dip samples used to provide the basis of the existing sludge. Because the projections for 1987 and beyond do not provide separate analyses for the sludge and supernatant, assumptions on the distribution of components to the sludge and supernatant had to be made. Ions such as Na^+, AlO_2^-, OH^-, SO_4^{-2} and F^- are assumed to be distributed evenly between the supernatant and the interstitial liquids in the sludge. In addition, a small fraction of these soluble ions are assumed to settle with the solids in the sludge. This fraction is based on the wash factors shown in Table 3-4 (Gibson 1987). All of the relatively insoluble ions such as calcium, magnesium, iron, manganese, and noncomplexed chromium, are assumed to settle with the sludge.

Table 3-4. Wash Factors Used to Determine Distribution of Soluble Ions in Plutonium Finishing Plant Sludge (Gibson 1987).

Soluble ion	Wash factors	
	Soluble fraction	Insoluble fraction
Na^+	98.6%	1.4%
AlO_2^-	93%	7.0%
F^-	98.6%	1.4%
SO_4^{-2}	98.6%	1.4%
OH^-	98.6%	1.4%

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3.3 COMPLEXANT CONCENTRATE

Complexant Concentrate is a TRU waste containing greater than 10 g/L of organic complexants (Riley 1988b). Complexants are primarily composed of degradation products of (EDTA) ($C_{10}H_{16}O_8N_2$), (HEDTA) ($C_{10}H_{18}O_7N_2$), citric acid ($C_6O_7H_8$), and oxalic acid ($C_2O_4H_2$) (Kurath 1985). The CC is presently stored in five DSTs: 102-AN, 107-AN, and 101-AY in the 200 East Area and 101-SY and 103-SY in the 200 West Area.

The composition of CC is given in Table 3-5. It is composed of 15,800 m^3 (4,180,000 gal) of supernatant and 352 m^3 (93,000 gal) of sludge. Except for sodium in the CC sludge, the compositions of the supernatant and sludge are based on the 1988 version of the Waste Generation and Process Rates with Volume Reduction Factors draft report (Riley 1988b). The concentration of sodium solids is based on a composite of analyses from tanks 107-AN and 102-AN and an assumed concentration of 10 wt% from tank 101-AY (Kurath 1985). The assumed compositions exclude any future salt-well liquid that may be complexed.

No data are given for sulfur content in the sludge. Because some sulfur in the supernatant should be associated with the sludge, a basis for quantifying the amount of sulfur in the sludge was developed. Wash efficiency factors reported by Gibson (1987) for NCAW were assumed for determining the percentage of sulfur associated with the sludge.

Since the allowable sulfur concentration in waste feed to the vitrification process is quite low, verification of sulfur concentration in the sludge is important and should be an objective of future characterization work.

Table 3-5. Composition and Volume of Complexed Concentrate Waste. (Sheet 1 of 2)

Component (g-mol/L)	Total	Sludge	Supernatant
OH-	0.543	6.258	0.146
Na	10.151	3.444	10.300
Al	0.713	0.944	0.708
Fe	0.045	1.342	0.016
Mg	0.014	0.589	0.001
Mo	0.005	0.027	0.004
Cr	0.018	0.241	0.013
Mn	0.019	0.341	0.012
Ca	0.016	0.136	0.013
Pb	0.001	0.000	0.001
Zr	0.002	0.044	1.23 E-03
Si	0.110	4.933	0.003
Ba	0.000	0.017	0.000
La	0.003	0.087	0.001
Ni	0.008	0.019	0.007
SO_4-	0.095	0.061	0.097
F-	0.123	0.000	0.126
NO_3-& NO_2-	4.559	0.000	4.660
PO_4^{-3}	0.045	0.000	0.046
CO_3-	0.921	0.135	0.938
Cl-	0.119	0.000	0.122
Component (g/L)	Total	Sludge	Supernatant
TOC	38.5	34.63	38.6

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Table 3-5. Composition and Volume of Complexed Concentrate Waste. (Sheet 2 of 2)

Component (Ci/L)	Total	Sludge	Supernatant
Pu	5.0 E-04	0.004	4.15 E-04
Eu	0.005	0.000	5.03 E-03
Am	0.001	0.018	4.93 E-04
^{90}Sr	0.136	0.000	0.139
^{137}Cs	0.358	0.000	0.366
^{60}Co	0.001	0.000	0.001
Stream vol (m^3)	16,141	352	15,789

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3.4 NEUTRALIZED CLADDING REMOVAL WASTE

Neutralized cladding removal waste is generated from the dissolution of zircaloy cladding from N Reactor fuel. The dissolving solution, consisting of NH_4F/NH_4NO_3 (AFAN) and the dissolved cladding material, is neutralized with NaOH after being transferred from the dissolver. The waste that is formed is a slurry consisting predominantly of zirconium, fluoride and sodium. The existing sludge is stored in tanks 103-AW and 105-AW.

The NCRW composition is based on Carothers (1987) and is given in Table 3-6. The composition, based on core and dip samples of pre-1987 sludge, is also assumed for future projected NCRW sludges. The sludge volume for NCRW generated through FY 1987 was 2,230 m^3 (590,000 gal). Original estimates showed that NCRW would no longer be a TRU waste after 1987 because of the incorporation of the rare earth nitrate precipitation process at the PUREX facility. However, recent projections show that the cutoff date for no longer generating TRU waste from NCRW will be closer to the end of FY 1989. According to projections, an additional 779 m^3 (206,000 gal) will be generated in 1988 and 1989 (Ludowise 1988). Consequently, a total volume of 3,010 m^3 (796,000 gal) of NCRW will need to be treated in the pretreatment facility.

3.5 SINGLE-SHELL TANK WASTE

The SSTs generally contain a layer of sludge covered with a layer of salt cake. Salt cake is a mixture of various sodium salts, namely $NaNO_3$, $NaNO_2$, $NaAlO_2$, NaOH, Na_2SO_4 and Na_3PO_4. In addition to these salts, sludges contain hydrated oxides of insoluble metal ions, such as iron, chromium, nickel, aluminum, cadmium and silicon. Much of the silicon is expected to have reacted with aluminates, hydroxides, and $NaNO_3$ to form cancrinite, which is difficult to retrieve. Table 3-7 provides the estimated sludge and salt cake compositions (Higley and Schulz 1988).

Table 3-6. Composition and Volume of Neutralized Cladding Removal Waste.

Component	Sludge composition (g-mol/L)
OH^-	0.869
Na^+	6.709
K^+	0.249
AlO^{2-}	0.134
F^-	5 296
$CA(OH)_2$	0.028
$Fe(OH)_3$	0.060
$Mn(OH)_2$	0.030
$Cr(OH)_3$	0 027
$La(OH)_3$	0.003
$Zr(OH)_4$	1 050
$Sn(OH)_2$	0.008
NO_3-& NO_2-	0.793
Component (Ci/L)	Sludge composition
^{238}U	2.70 E-06
$^{239,240}Pu$	8.84 E-04
^{241}Pu	8.11 E-03
^{241}Am	5.47 E-04
^{90}SrY	0.010
$^{137}CsBa$	0.034
Stream vol (m^3)	3010

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Table 3-7. Estimated Sludge and Saltcake Compositions in Single-Shell Tanks. (Sheet 1 of 2)

Component (g-mol/L)	Sludge	Saltcake
$NaNO_3$	5.144	14.333
$NaNO_2$	0.950	0.659
Na_2CO_3	0.351	0.082
NaOH	2.295	0.742
$NaAlO_2$	0.253	0.449
Na_2SO_4	0.114	0.130
Na_3PO_4	1.667	0.157
Cancrinite	0.088	0.000
$Al(OH)_3$	0.645	0.000
$Ca(OH)_3$	0.037	0.000
$Cr(OH)_3$	0.040	0.000
$Cd(OH)_2$	0.001	0.000
$Fe(OH)_3$	0.245	0.000
$Sr(OH)_2$	0.008	0.000
$BiPO_4$	0.027	0.000
$CaCO_3$	0.070	0.000
Cl^-	0.025	0.000
Hg^+	0.000	0.000
F^-	0.921	0.003
MnO_2	0.048	0.000
$Ni_2Fe(CN)_6$	0.033	0.000
SiO_2	0.000	0.000
$P_2O_5 \cdot 24WO_2$	0.000	0.000
$ZrO_2 \cdot 2H_2O$	0.059	0.000
U	0.131	0.000
Th	0.000	0.000

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Table 3-7. Estimated Sludge and Saltcake Compositions in Single-Shell Tanks. (Sheet 2 of 2)

Component (g/L)	Sludge	Saltcake
^{241}Am	1.79×10^{-4}	0.000
^{237}Np	1.02×10^{-3}	0.000
^{239}Pu	7.76×10^{-3}	0.000
^{240}Pu	5.11×10^{-4}	0.000
Volume (m^3)	45,700	92,400

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There are 149 SSTs at the Hanford Site, and the selection of the type of treatment (i.e., in-place disposal versus retrieval, pretreatment, and processing) has been deferred pending further evaluation (Final Hanford Defense Waste Environmental Impact Statement 1988, Record of Decision 1988).

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4.0 WASTE TREATMENT PROCESS ALTERNATIVES

Alternatives for pretreatment of DST and SST wastes are described in this section. The elements, analyses, and results which lead to the selection of a preferred process are described. The proper choice of pretreatment options will ensure that the most cost-effective method to meet environmental and regulatory standards for final disposal of Hanford Site wastes is used. The overall goal of processing Hanford Site tank waste is to reduce disposal costs by reducing the volume of waste that must be vitrified and disposed of in a deep geological repository. To accomplish this goal, consideration is given to processes that efficiently partition the waste into (1) a large, low-level waste fraction suitable for less expensive, near-surface disposal in grout form and (2) a much smaller fraction of TRU (>100 nCi/g TRU) and/or high-level waste that must be vitrified and consigned to a geologic repository.

4.1 DESCRIPTION OF WASTE PROCESS ALTERNATIVES

Two processing alternatives are considered for all waste types:

- Separation of solids or sludges from supernatant liquids and washing of solids with water to remove soluble salts

- Solid-liquid separations coupled with sludge dissolution and removal of TRU components from acidic waste solutions using the TRUEX process.

Other pretreatment methods are specific to a particular waste type. Pretreatment methods specific to NCAW and CC wastes are as follows:

- Removal of radiocesium from alkaline NCAW supernatant liquors

- Destruction of complexants in CC to remove complexed TRU elements and/or provide a feed for grouting that is free of organic constituents.

Based on input from outside agencies (NRC, EPA and Washington State) and future comprehensive performance assessments, it may be desirable to reduce the concentrations of radionuclides in LLW grouts to significantly lower levels than those defined by the current grout criteria. Radionuclide concentrations based on Class C levels (10 CFR 61) are presently assumed; however, preparation of LLW grouts with radionuclide contents less than or equal to Class A levels may be desirable. The primary radionuclides of concern and considered as candidates for additional radionuclide removal are ^{90}Sr, ^{137}Cs, and the TRU components. Major pretreatment process changes will be required to reduce radionuclide contents of waste supernatants by the approximate factors of 10-1000 needed. In this report it is assumed that pretreatment processes to reduce ^{90}Sr, ^{137}Cs, and TRU concentrations in grout feed to levels comparable to Class A will not be required. However, the potential impacts of treating the waste to further reduce radionuclide concentrations in LLW supernatants are addressed in Section 7.0.

Table 4-1 is a matrix of applicable processing options for each waste type. Simplified conceptual flow diagrams of the pretreatment options for each waste type are provided in Appendix A. Chemical process flowsheets of the baseline TRUEX process for PFP wastes, NCRW and CC are also included in Appendix A.

Table 4-1. Process Options for Each Waste Type.

Waste type	Sludge washing	TRUEX	Strontium removal	Cesium removal	Complexant destruction
NCAW	X	X	X[a]	X[b]	
PFP	X	X			
NCRW	X	X			
CC	X	X			X
SST	X	X			

[a]Required if TRUEX process is used for NCAW.
[b]Cesium removal from NCAW supernatant is required for all NCAW process options.

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Following are descriptions of the waste pretreatment process alternatives.

4.1.1 Solid-Liquid Separations and Sludge Washing

Solids are separated from supernatant liquors using washing, settle-decant, and filtration methods. After initial separation of solids and supernatant liquors, water is added to the solids, and the slurry is thoroughly agitated. After gravity settling of undissolved solids, a pneumatic hydropulse (PHP) filter is used to provide adequate clarification of supernatant liquids (Gibson and Landeene 1987). Washing of the solids reduces the amount of waste requiring vitrification by removing water soluble components. Washing also removes soluble species such as sulfates, which interfere with the vitrification process.

Water washing of solids can be performed directly in DSTs for PFP, NCRW and CC. Mixer pumps used for waste retrieval operations are expected to provide adequate in-tank sludge washing capabilities, assuming the wastes can be adequately suspended and mixed. Water washing NCAW sludge in a DST is an option to washing NCAW sludges in the B Plant facility as a result of the decision to place the N Reactor in cold standby (see Section 5.0). For

wastes that have the potential to be washed in DSTs, PHP filtration may be adapted for tank farm use (Place 1988a). Clarified washes will be combined with the salt solution from the first water treatment step.

4.1.2 Transuranic Extraction Process

The TRUEX process is a recently developed liquid-liquid extraction process capable of extracting actinide elements with +3, +4 and +6 oxidation states from HNO_3 waste solutions (Horwitz and Schulz 1985, 1986, 1987). A commercially available bifunctional organophosphorus reagent, octyl(phenyl)-N, N-diisobutylcarbamoylmethylphosphine oxide (CMPO), is used as the extractant in the TRUEX process. The TRUEX process solvent effectively extracts actinides over a wide range of aqueous feed acidities (e.g., 0.5M to 8M HNO_3). Bench-scale batch and countercurrent tests have demonstrated that the TRUEX process can be used to convert many TRU-type wastes (i.e., $\geq$100 nCi TRU elements/g of waste) to LLW suitable for disposal in near-surface facilities.

The TRUEX process can be applied to alkaline supernatant liquors that have been acidified, e.g., complexant concentrate (Kurath 1985) or to sludges that have been dissolved in hot nitric acid (HNO_3). Limited experimental data exist on the dissolution of sludges. Except for CC solids, 75 wt% of DST waste sludges is assumed to dissolve in HNO_3 (Rasmussen 1980); undissolved sludges are assumed to require immobilization for geologic disposal. For purposes of this evaluation, it is assumed that hot HNO_3 followed by oxalic acid ($H_2C_2O_4$) solutions will be required to dissolve SST sludges. Still, only 70 wt% of the SST sludge is assumed to dissolve because of anticipated mineral (i.e., cancrinite) formations in the tanks (Higley and Schulz 1988).

The TRUEX process is used to remove uranium and TRU elements from the HNO_3-$H_2C_2O_4$ solution. It is assumed that the TRUEX process will be operated to selectively partition (strip) the TRU elements from coextracted uranium. The separated TRU elements are combined with the undissolved sludge and then vitrified in the HWVP.

The aqueous raffinate from the TRUEX process is made alkaline by addition of NaOH and then combined with the sodium carbonate solution used to strip uranium from the CMPO solvent. The resulting solution is expected to be suitable for disposal in grout in near-surface facilities. However, grout formulation development is needed to verify the suitability of the raffinate for grout for each waste type.

4.1.3 Radio-Cesium Removal

Removal of ^{137}Cs from NCAW supernatant liquor is required to ensure a LLW feed to the GTF (Gibson 1987). Duolite CS 100* resin is used to remove 95% of the cesium from the filtered NCAW supernatant feed stream. A second cycle of ion exchange (IX) is required to further separate cesium from sodium.

Before the second IX cycle is performed, the acidic cesium eluate stream from the first IX cycle is concentrated (to minimize the volume requiring lag storage) and neutralized. The second cycle ion exchange process then follows the same steps as the first cycle. The final cesium stream is concentrated and stored as feed for vitrification. Cesium-free waste streams from the first and second IX cycles are routed through the low-level waste concentrator to the tank farms for interim storage as feed for the grout process.

4.1.4 Strontium Removal

Pretreating the sludge fraction of NCAW by the TRUEX process will result in a high concentration of ^{90}Sr to grout. Thus, to reduce the heat loading and activity level in grout, removal of ^{90}Sr from the acidic TRUEX

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*Duolite CS 100 is a registered trademark of Rohm and Haas, Philadelphia, Pennsylvania.

process raffinate is required. A rare-earth sulfate-strike method to precipitate ^{90}Sr from acidic solutions has been utilized at the B Plant facility. The pH of the acidic raffinate from the TRUEX process is adjusted to between 1 and 2 with Na_2CO_3. Next, sodium sulfate is added to the raffinate to a 1M concentration. Rare earth nitrate is then added in small concentrations to precipitate rare earth strontium sulfate from the raffinate. Since relatively few alkaline earth elements, such as Ca or Mg, exist in NCAW, the precipitate can then be directed to the HWVP feed tank with minimal impact to the glass composition. Bray et al. indicate a greater than 95% strontium removal from the raffinate is possible with a single strike, however, B Plant data indicate significantly less efficiencies are achieved (Joyce 1983). The 95% value will reduce the maximum heat loading from a projected maximum of 8.5 W/m^3 to less than 0.42 W/m^3. When accounting for cesium, this value approaches the maximum heat load for grout. Based on thermal modeling performed with Double-Shell Slurry feed, which establishes the grout heat loading limit from fission products at 1.23 W/m^3, the reduced heat loading attained by strontium removal appears to be marginally acceptable. Higher strontium removal efficiencies will be necessary to make the TRUEX process adaptable to NCAW. Other candidate ^{90}Sr removal processes are also described by Higley and Schulz 1988. Section 7.0 of this report describes in detail the implications of removing ^{90}Sr from grout feed streams.

4.1.5 Complexant Destruction

Alkaline CC liquors contain significant amounts of organic compounds which form soluble chemical complexes with TRU elements. Before the alkaline CC can be incorporated into grout, the TRU elements must be removed. One method of TRU element removal is to destroy the organic complexants in CC, thereby precipitating certain cationic elements including the TRU elements from solution. This precipitate (primarily hydrated iron oxide contaminated with TRU elements) constitutes feed to the HWVP while the complexant-free solution can be converted to grout.

The TRUEX process can also be used to remove TRU elements from acidified CC (Section 4.1.2). Kurath (1985) concluded that the TRUEX process was more economical than complexant destruction for removing TRU elements since a high volume TRU-bearing precipitate does not result from the TRUEX process. The TRUEX process does not destroy the organic complexants, however, and the LLW solution fed to grout will still contain the organic complexants. The ability of grout to accept organic components for disposal in near-surface facilities at the Hanford Site has not yet been established. If organics are not acceptable in grout, either from a regulatory or a physical and chemical compatibility standpoint, complexant destruction may still be applied to the TRUEX process raffinate. If a LLW feed to grout that does not contain organic constituents is required, complexant destruction of the TRUEX process raffinate may prove to be less costly than complexant destruction alone.

Kurath (1985) evaluated alternatives for removal of TRU elements from CC by destruction of organic complexants. The most promising alternatives are oxidation with super critical water (i.e., temperatures and pressures above the critical point of water) and oxidation with hydrogen peroxide (H_2O_2). Because of safety concerns associated with high temperature and pressure, oxidation with H_2O_2 is used as the reference method for evaluation in this study.* The waste is acidified to a pH <1 to facilitate the reaction. The waste is then heated to near boiling to increase the rate of the reaction and to ensure that all H_2O_2 has reacted. Hydrogen peroxide is added continuously, followed by a 2-h digestion period where all H_2O_2 is decomposed to O_2 and H_2O. The waste is then neutralized and the solids are separated. The low level waste supernatant is sent to grout, and the TRU

*Since the Kurath 1985 study was completed, recent additional technologies for destroying complexants have been identified. Kurath (1988) describes an electrochemical oxidation method presently being developed by PNL. Further, detailed evaluation of potential organic destruction methods other than H_2O_2 are recommended.

solids are sent to the HWVP. In the cases where complexant destruction is performed on TRUEX process raffinate, the solids will be low-level waste and can be immobilized in grout.

Section 5.0 evaluates facility options for performing the pretreatment processes described in this section. One option utilizes sludge washing in double-shell tanks for pretreatment of all candidate wastes. For this approach it is assumed that the TRU components will be removed from CC supernatant liquors using in-tank complexant destruction. The complexant destruction method that appears most amenable for in-tank use is ozonization (see Section 5.2.5). The ozonization process (Kurath 1985) utilizes ozone (O_3) to oxidize the heavy metals and the organics in the CC. Ozone is generated at 1.5 to 2.0 wt% from air or oxygen by passing the air through a high frequency electric field. The ozone in the gas diffuses into the liquid where it decomposes or reacts with one of the many components in the CC. Most of the heavy metals including the TRU are precipitated as metal hydroxides or metal oxides. Some of the TOC remains in the wastes as low molecular weight organic compounds (such as oxalate) while some is oxidized to CO_2. The solids are separated in the tank using settle-decant. Washed solids are sent to the glass plant. The non-TRU liquid waste is sent to the grout plant.

4.1.6 Selective Leaching

Preliminary studies have indicated that selective leaching of washed NCRW sludge with dilute acids could significantly reduce the volume of waste vitrified. Swanson (1987) has shown the potential for removing 60% of plutonium and 90% of the americium by this technique. The remaining sludge would be disposed in grout form, and the TRU-bearing supernatant would be vitrified. Considerable development of this process is necessary, however, before selecting this technique as a preferred pretreatment option. Therefore, this option has not been considered further in this report.

4.2 EVALUATION OF PROCESS ALTERNATIVES

Estimates of the amounts of glass and grout products which will result from application of waste pretreatment to Hanford Site DST and SST waste processes are shown in Table 4-2. The incentives for use of the TRUEX process to reduce the number of canisters of glass that must be disposed of in a HLW geologic repository are apparent. Calculations used to derive the glass and grout volume estimates are provided in Appendix A.

Table 4-3 compares the costs in FY 1988 dollars for the two major levels of waste treatment; i.e., simple sludge washing versus TRU removal using the TRUEX process. For certain processing scenarios, advantages can potentially be realized by sludge washing a portion of the waste and applying the TRUEX process to the remaining waste. Thus, facility operational costs can potentially be minimized by reducing the pretreatment operating time and HWVP standby time. Table 4-3 also shows pretreatment costs for combined sludge washing/TRUEX process cases. Detailed descriptions and evaulation of this operational concept is provided in Section 5.0, "Waste Treatment Facility Alternatives." The costs shown in Table 4-3 are those required for implementation of the options, and for processing and disposal of the candidate DST wastes. The costs for the TRUEX process option include those for upgrading existing facilities versus those for construction of new facilities--thus a range in implementation and operational costs is shown. Cost details for the facility options are provided in Section 5.0. The major operational assumptions and cost bases used in this report for cost estimations are provided in Appendix B. A discount rate cost analysis was also applied to the waste pretreatment options (Appendix C). The information in Appendix C indicates that the use of a constant dollar analysis is adequate for comparing costs of the various pretreatment options since application of a discount rate analysis does not change the conclusions in this report.

Table 4-2. Glass and Grout Volumes.

Waste type	Processing alternative	Grout volume (m^3)	Total canisters[a]
PFP	Sludge washing	720	400
	TRUEX	2,100	100
CC	Complexant destruction	68,000	870
	TRUEX	74,000	580 (150)[b]
	TRUEX plus complexant destruction	74,000	580 (150)[b]
NCRW	Sludge washing	5,100	1,600
	TRUEX	9,800	400
NCAW	Sludge washing	14,000	480
	TRUEX	20,000	120
Single-shell tank waste			
12 tanks	Sludge washing	19,000	2,800[c]
	TRUEX	34,000	880[c]
75 tanks	Sludge washing	280,000	15,000[c]
	TRUEX	370,000	5,100[c]
149 tanks	Sludge washing	580,000	24,000[c]
	TRUEX	710,000	7,600[c]

[a]0.627 m^3 glass/canister.
[b]In this study it is conservatively assumed that the CC solids do not dissolve in HNO_3. If 75 percent of the solids dissolved, however, the number of canisters of glass would be reduced from 580 to 150.
[c]From Higley and Schulz, 1988.

PST88-3209-4-2

Table 4-3. Pretreatment Process Costs for Double-Shell Tank Waste (Millions, Fiscal Year 1988 Dollars).

Cost element	Process options		
	Sludge washing[a]	Sludge washing/ TRUEX[b]	TRUEX
Pretreatment capital	140	220	220
Pretreatment operations[c]	320-720[d]	560-660[e]	600
Vitrification operations[f]	660	350-520[e]	310
Grout operations and disposal	130	180	180
HLW repository disposal	1,200	520-550[e]	420
HWVP capital[g]	920	920	920
Miscellaneous	80	100	100
Total (rounded)	3,400-3,800	2,850-3,150	2,750

[a]Assumes complexant destruction rather than TRUEX process is performed on complexant concentrate in B Plant (see Section 5.0).

[b]Assumes sludge washing is performed on NCAW or PFP waste and the TRUEX process is applied to remaining waste (see Section 5.0).

[c]Assumes B Plant is used for pretreatment operations except for cases where sludges are washed in DSTs.

[d]Range shown reflects costs for all pretreatment operations in DSTs versus costs for pretreatment operations in both DSTs and B Plant (see Section 5.0).

[e]Ranges shown reflect different sludge washing/TRUEX options described in Section 5.0.

[f]Assumes use of large capacity melter (100 kg glass/h).

[g]Note this cost is escalated to mid-point of construction rather than FY 1988 dollars.

PST88-3209-4-3

The information in Table 4-3 shows that it is highly cost effective to apply TRUEX process technology to DST waste sludge and CC supernatants. Cost savings for conducting TRUEX process operations with DST wastes instead of just sludge washing range from approximately 600 million to 1 billion dollars. The potential cost reduction for in-tank washing a portion of the waste and applying the TRUEX process to the remaining waste, instead of just sludge washing ranges from 250 million to 950 million dollars. Higley and Schulz (1988) estimate cost savings for applying TRUEX to SST wastes range from 600 million to 9 billion dollars depending on the SST waste retrieval option evaluated.* The greatest cost savings result from substantial reductions in HWVP operational expenditures and fees for geologic disposal of vitrified wastes.

The number of canisters of glass listed in Table 4-2 for the TRUEX process alternative is directly related to the amount of sludge that remains undissolved in the acid dissolution step that precedes the TRUEX process. The assumption that 75% of the DST waste sludge and 70% of the SST waste sludges can be dissolved is considered realistic but needs to be confirmed by performing dissolution tests with actual representative waste samples. The economic incentives for the TRUEX process increase even more substantially if more sludge can be dissolved. Experimental work should be directed as soon as possible to finding practical means of dissolving 90 to 95% of washed DST and SST sludges.

The need for destroying complexants in CC to provide an acceptable grout has not been established. Treatment of CC using the TRUEX process removes the TRU components from the supernatant but leaves the organic compounds in the grout feed. An additional treatment step to destroy the complexants (i.e., TRUEX process plus complexant destruction) can be

*Three retrieval cases were evaluated which are believed to bound the range of reasonable alternatives. The three retrieval alternatives included retrieval of waste from (a) 12 SSTs (b) 75 SSTs (c) 149 SSTs.

performed with no increases in canisters of glass or grout volumes (Table 4-2). It is conservatively assumed in this report that the TRUEX process and complexant destruction will both be required for CC. The TRUEX/complexant destruction combination would cost approximately 30 million dollars more than a TRUEX process alone because one year of additional processing time and additional processing equipment and chemicals (H_2O_2) are required (Place 1988a).

4.3 SUMMARY AND RECOMMENDATIONS

There are clear-cut technical and economic incentives for implementing the TRUEX process for application to DST and SST wastes. The TRUEX process should be strongly considered for application to PFP, NCRW, CC, and SST waste sludges. The application of the TRUEX process to NCAW should be considered if methods for ^{90}Sr removal from dissolved NCAW sludge can be developed and implemented in time to support the scheduled startup of the HWVP.

Following are recommendations for development work. For additional details relating to these recommendations refer to Section 7.0, "Technical Issues."

- Accelerate characterization of candidate wastes to the pretreatment processes.

- Develop technology through bench and pilot scale tests for dissolution of waste sludges. Develop TRUEX process flowsheets on an immediate basis.

- Develop methodology for removal of ^{90}Sr from acidic solutions resulting from dissolution of NCAW sludge. Also perform engineering study of complexant destruction in a DST.

- Assuming that organic complexants will be unacceptable in grout, develop methodology for destroying complexants in acidic TRUEX process raffinate.

- The potential economic incentives for performing selective leaching of NCRW indicates a need for continuing development of this option.

- Develop appropriate grout and glass formulations based on TRUEX process flowsheets.

- Perform studies to evaluate methods and impacts of reducing radionuclide concentrations in grout to levels comparable to those defined in 10 CFR 61.

5.0 WASTE TREATMENT FACILITY ALTERNATIVES

Facility options for performing the waste treatment processes recommended in Section 4.0 are evaluated in this section, and a preferred waste treatment and facility option is presented. Section 4.0 stressed the economic incentives for applying the TRUEX process to reduce the volume of waste feed that must be vitrified and consigned to a geologic repository. To achieve this goal, development of methodology to verify that the TRUEX process can be successfully applied to the candidate wastes is required. The option of simple sludge washing of all wastes rather than using the TRUEX process must be kept open until the appropriate TRUEX process technology has been developed. A decision analysis is presented in Appendix D which graphically depicts on a time scale the technical and programmatic decisions required to arrive at a preferred pretreatment plan.

Four facility options are evaluated as possible locations where TRUEX process pretreatment operations could be performed:

- B Plant
- PUREX facility
- A new stand-alone facility
- An expanded HWVP.

The waste pretreatment processes considered for these facility options are those recommended for further evaluation in Section 4.0, i.e., the TRUEX process, strontium removal, and cesium removal for NCAW; the TRUEX process on dissolved PFP and NCRW sludges; and the TRUEX process combined with complexant destruction for CC sludges and supernatant.

For cases where sludge washing of DST wastes is performed instead of utilizing the TRUEX process, it is assumed that PFP, NCRW, and CC solids can be washed directly in DSTs using mixer pumps. Two facility alternatives are considered, however, for washing NCAW sludge: (1) B Plant and (2) DSTs. Washing NCAW sludge in a double-shell tank or AR Vault rather than washing in B Plant is an option as the result of the decision to place the N Reactor in cold standby. Originally the pretreatment system had to provide the capability of processing current discharged fuel waste. Irradiation of N Reactor fuel was complete in 1986 and all FFTF mixed-oxide fuel will be complete in 1991. Pretreatment processing of NCAW is all on aged waste and previous heat transfer limitations are less restrictive to the extent that the small 5,000 gal batch size used in B Plant may no longer be required. A detailed engineering study and safety evaluation need to be performed on a priority basis to confirm the feasibility of washing NCAW solids in a DST. For wastes that have the potential to be washed in DSTs, PHP filtration may be adapted for tank farm use (Place 1988a). Clarified washes will be combined with the salt solution from the first water treatment step.

As discussed in Section 4.0, use of facilities for sludge washing a portion of the waste and applying the TRUEX process to the remaining waste is also addressed in this section. A significant portion of the cost savings from application of the TRUEX process to all DST waste results from reducing operational costs associated with washing NCAW at B Plant. Other reductions are attributed to reduced vitrification operating costs and reduced disposal costs resulting from production of fewer canisters of glass. Washing a portion of sludge waste in a DST rather than B Plant would significantly reduce the operating time and operational costs required for washing, which could compensate for the increase in the number of canisters of glass. Additional feed for HWVP could be provided in parallel with TRUEX process treatment and would enable continuous operations (and possibly early startup) of the HWVP. Thus, washing PFP sludge in a DST (or alternatively washing a portion of NCRW sludge) rather than washing NCAW sludge in B Plant is evaluated as an option. Washing NCAW in a DST is also evaluated as an

alternative to washing NCAW in B Plant. The remaining waste would be treated using the TRUEX process at either B Plant, a new stand-alone facility, the PUREX facility, or an expanded HWVP.

Table 5-1 summarizes the array of processing/facility options and combinations evaluated in this report. As mentioned in Section 1.0, the current baseline processing/facility option is sludge washing NCAW in B Plant and utilization of the TRUEX process in B Plant for the remaining DST wastes.

Table 5-1. Candidate Process/Facility Options.

1.	TRUEX process all waste (all facility options[a])
2.	Sludge wash NCAW (B Plant or DST); TRUEX remaining waste (all facility options[a])
3.	Sludge wash PFP waste (double-shell tank); TRUEX remaining waste (all facility options[a])
4.	Sludge wash all wastes (DST) or [B Plant (NCAW) + DST remaining waste]

[a]B Plant, PUREX facility, new stand-alone facility, or expanded HWVP for TRUEX processing.

This section presents: (1) a discussion of pretreatment processing equipment for each facility option, (2) a description of the candidate facilities, (3) a comparison of considerations affecting facility selection, (4) observations and conclusions relating to the facility options, and (5) a description of the preferred process and facility option. Important bases and assumptions followed in this evaluation are listed in Appendix B.

5.1 PRETREATMENT PROCESSING EQUIPMENT

5.1.1 Equipment Sizing

The facility pretreatment equipment requirements and capabilities for supporting a 45 kg/h HWVP melter and a 100 kg/h HWVP melter are described in this section and are provided by Place (1988a). The design basis of the HWVP will provide capabilities to produce 100 kg of high-level waste glass per hour of melter operation (Westinghouse 1987). However, it is envisioned that initial operations will incorporate a smaller capacity melter which produces 45 kg of glass per hour. In this study, the baseline case assumes that a 45 kg/h melter will be used with DST waste and a 100 kg/h melter will be required to process the large volumes of SST wastes (Higley 1988). Since the HWVP is not currently committed to this case, the cost and schedule impacts of waste vitrification at the 100 kg/h rate for both DST and SST waste are also assessed.

Since waste from SSTs is potentially the largest volume of waste that will require pretreatment and vitrification, the equipment in a new stand-alone facility or expanded HWVP was initially sized to provide adequate throughput of SST waste to support continuous operation of the 100 kg/h melter (Place 1988a). It is estimated that 24 yr of HWVP processing time will be required to vitrify the TRUEX-processed waste from all 149 SSTs (Higley and Schulz 1988). Detailed evaluation of DST waste process flowsheets and schedules show that this equipment size does not provide adequate pretreatment processing rates for all DST wastes. Thus, operation of the large 100 kg/h melter could result in frequent standby periods when vitrifying DST waste. The equipment sizes for the new stand-alone and expanded HWVP facilities were thus increased accordingly to ensure minimal schedule impacts when processing DST wastes. The rate-limiting step for treatment of NCRW, PFP, CC and SST waste sludges is the acid dissolution step which precedes removal of the TRU components from the dissolved sludges. Two sludge dissolution tanks with total dissolution capacities of 320,000 L (i.e., two 42,000 gal tanks) would provide feed to the TRUEX

process at a rate that would ensure continuous operation of the HWVP 100 kg/h melter with DST sludges. Due to the different properties of SST sludges, only 160,000 L total dissolution capacity is required to ensure continuous operation of the HWVP 100 kg/h melter when processing SST sludges only.

The B Plant facility and PUREX facility could dissolve DST sludge wastes at rates that would support continuous operation of a 45 kg/h melter at the HWVP for approximately 8 yr followed by a 21 mo HWVP standby awaiting the next batch of pretreated waste (see Section 5.3). Because of the small sizes of the B Plant process cells, a total of three cells, each containing a 19,000 L (5,000 gal) dissolver (i.e., total of 57,000 L or 15,000 gal capacity) was assumed for the baseline plan (Place 1988a). The PUREX Plant could provide dissolution capabilities comparable to those of B Plant (Jacobs 1988). For B Plant or the PUREX facility to support the faster HWVP throughput rate for DST waste, much larger dissolution vessel capacities would be required. A preliminary assessment indicates that the total sludge dissolution capabilities in B Plant could possibly be increased from 57,000 L to 160,000 L which would provide adequate sludge dissolution capacity for SST wastes (Place 1988b). However, sludge dissolution capacities for DST wastes would be inadequate for some of the process scenarios listed in Table 5-1 which would result in standby of the HWVP.

5.1.2 Equipment Description

Figure 5-1 shows a simplified layout of the equipment that would be suitable for pretreatment of Hanford tank wastes. The sludge dissolver capacities shown in Figure 5-1 are representative of those in a new facility or expanded HWVP. As discussed in Section 5.1.1, the sludge dissolvers in B Plant would be smaller in size and the total capacity could vary from 57,000 to 160,000 L.

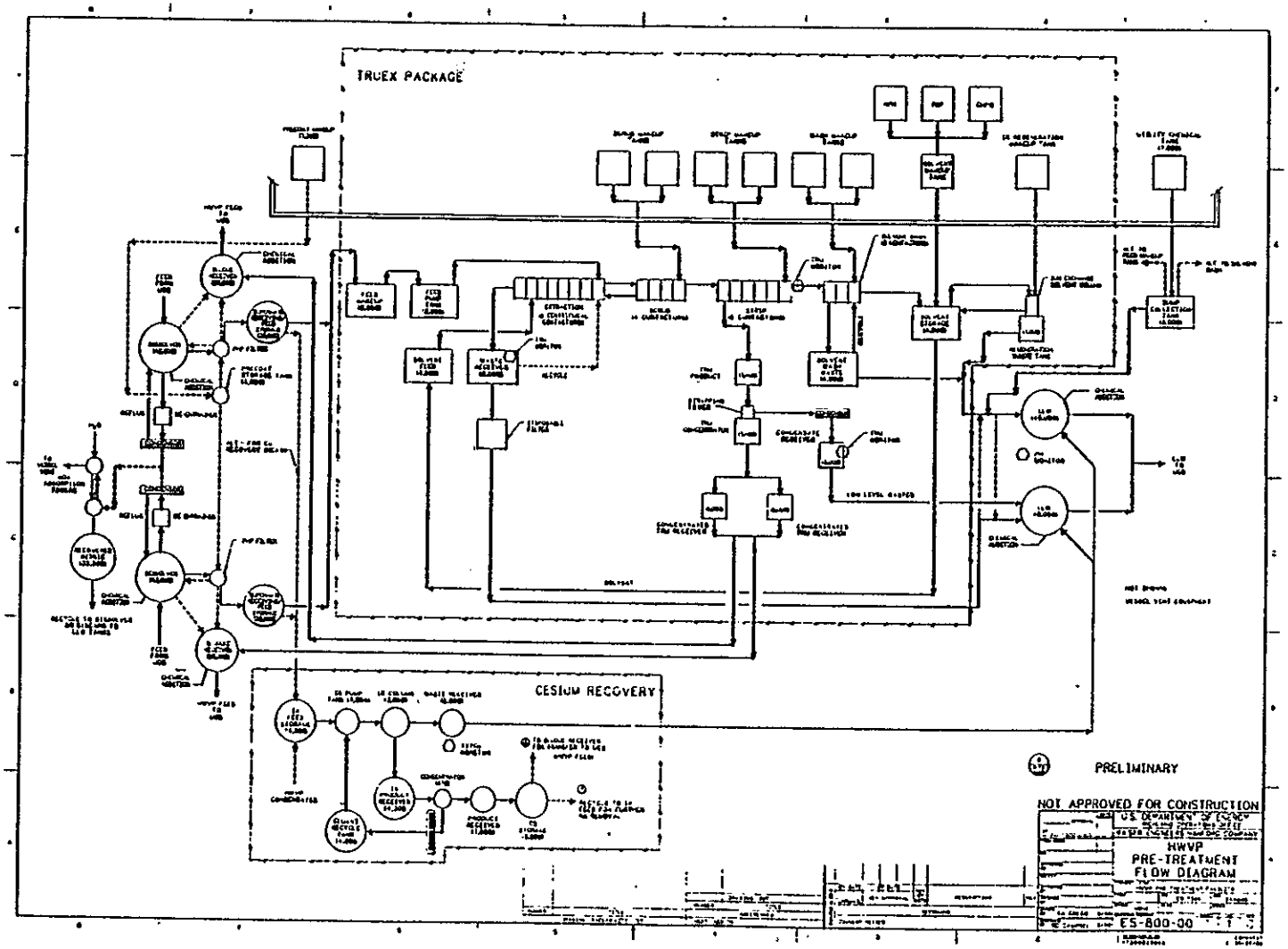

Figure 5-1. Conceptual Waste Pretreatment Process.

Since fluoride will be present in some waste feed to the acid dissolvers (e.g., PFP and NCRW sludge), the material of construction for the dissolvers in the candidate facilities is Hastelloy C.* However, adequate sludge dissolution may be possible in stainless steel equipment if aluminum nitrate [$Al(NO_3)_3$] is added to complex free fluoride. Laboratory tests need to be performed to verify that adequate sludge dissolution is indeed possible using $Al(NO_3)_3$ to complex free fluoride ion.

The TRUEX process flowsheet in B Plant or PUREX would be very similar to that postulated for a new facility or expanded HWVP (Figure 5-1). A continuous TRUEX process would likely be implemented using centrifugal contactors although pulse columns could be used at the PUREX facility. Centrifugal contactors operate over a far wider range of aqueous-to-organic flow ratios than pulse columns, and the number of stages can be easily changed thus allowing maximum flexibility to process all Hanford waste types. The maximum required capacity for the centrifugal contactors for all of the facility alternatives is estimated to be approximately 53 L (14 gal) per minute. Destruction of organic complexants in CC would be performed in the dissolution tanks using H_2O_2. Large aluminum H_2O_2 storage tanks with one to 3 mo storage capacity (about 450,000 L) would be required.

For the facility options involving no waste pretreatment operations at B Plant, installation of equipment for removing ^{137}Cs from NCAW supernatant is required in the new facilities. Cesium removal equipment is provided in the design for the new stand-alone or expanded HWVP facilities even for the cases where NCAW is washed in B Plant. This allows for uncertainties in unanticipated waste treatment requirements. Although not assumed in this study, it may be necessary to remove radiocesium from some SST waste salt cake solutions to provide an acceptable grout. Additionally, this cell

*Hastelloy C is a registered trademark of Cabot Corporation, Kokomo, Indiana.

space could be utilized if necessary for additional radionuclide removal (e.g., ^{99}Tc, ^{129}I, and ^{90}Sr) deemed to be required by future performance assessments or regulatory requirements. (See Section 7.0, "Technical Issues.")

5.2 FACILITY DESCRIPTIONS

Detailed descriptions of the required modifications for B Plant and the PUREX facility are provided by Place 1988a and by Jacobs 1988, respectively. Descriptions of the proposed new stand-alone facility and expanded HWVP are provided in Appendix E. Conceptual facility layouts are also shown. Following are brief descriptions of the pretreatment facility options.

5.2.1 B Plant

The B Plant facility is currently undergoing modifications to allow sludge washing and radiocesium removal from NCAW. The detailed flowsheet prepared by Gibson 1987 describes the B Plant pretreatment facility requirements for the option that involves only treatment of NCAW at B Plant. The costs for upgrading B Plant to perform sludge washing and cesium removal from NCAW is $93 million (Reep 1988).

Further modification to B Plant equipment/instrumentation would allow pretreatment of other Hanford tank wastes. Considerable renovation of several process cells would be required to implement the pretreatment processes (i.e., sludge dissolution, the TRUEX process and complexant destruction). A total of four existing process cells would contain the three 19000 liter vessels for sludge dissolution, complexant destruction, and associated off gas treatment, and five cells would be required for TRUEX process solvent extraction and associated equipment (Place 1988a). All new equipment would be used. Existing tanks and associated equipment would be disposed of. The estimated capital expenditures in FY 1988 dollars for this upgrade is $67 million (Appendix F). A proposed layout of the modified

B Plant facility is also shown in Appendix F. To support operation of a higher capacity melter at the HWVP approximately one or two additional B Plant cells could potentially be utilized and larger capacity dissolvers would be used (Place 1988b). Preliminary estimates indicate that additional expenditures of approximately $33 million (i.e., a total capital cost of $100 million) would be necessary (Appendix F). For the case where sludge washing of NCAW is performed in B Plant, rehabilitation of the B Plant cells and installation and testing of the TRUEX process equipment could not begin until FY 1999. A 1997 congressional line item is required to support this implementation schedule (Figure 5-2). If NCAW was not washed at B Plant (Table 5-1), TRUEX processing equipment could be installed as early as FY 1995 and full scale TRUEX process operations could begin in mid FY 1997. A 1994 congressional line item would be required to support this schedule (Figure 5-3).

5.2.2 New Stand-Alone Facility

The new stand-alone pretreatment facility is a remote canyon facility with parallel cells spanned by a single crane. A total of 116 lineal meters (380 ft) of cell space is estimated to be required for containing the proposed waste treatment equipment in Figure 5-1. The new facility would be located in the vicinity of HWVP and B Plant. The building is a Category I building with conservatively sized rooms for HVAC, closed loop cooling and heating, a laboratory, emergency generator and rail access for equipment ingress/egress from the canyon. Galleries 7.6 m (25 ft) wide surround the parallel cells on four levels to accommodate aqueous makeup, instrumentation, sampling, storage, maintenance and a hot shop. A pipe trench, closed loop room and air tunnel are positioned between the parallel cells to house service routings. A description and proposed layout of the new facility is provided in Appendix E.

The estimated capital cost in FY 1988 dollars for construction of a new stand-alone pretreatment facility is $242 million (Appendix E). The proposed schedule for implementation of a new stand-alone facility is shown

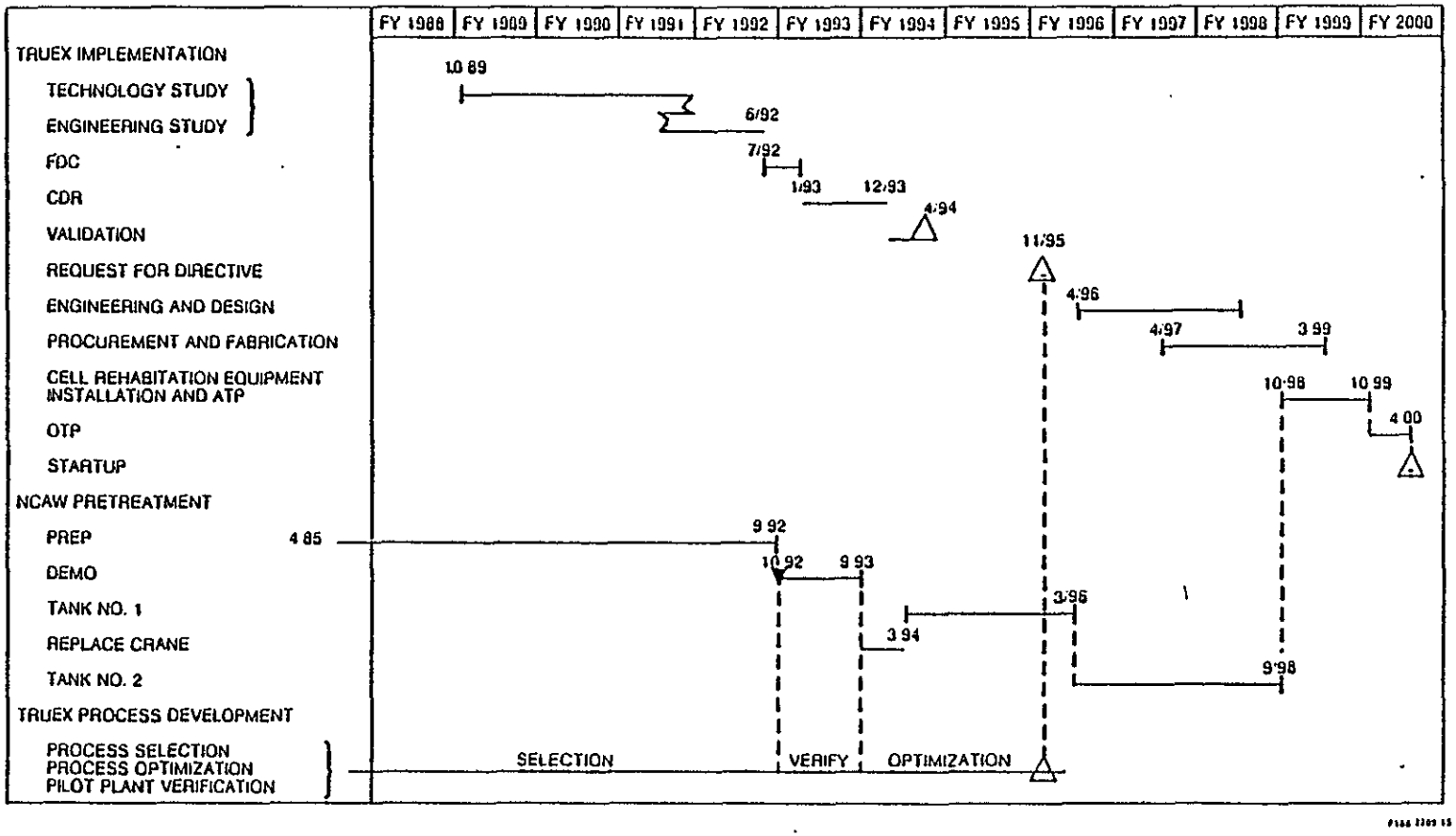

Figure 5-2. B Plant Pretreatment Facility Schedule TRUEX Implemented in FY 2000.

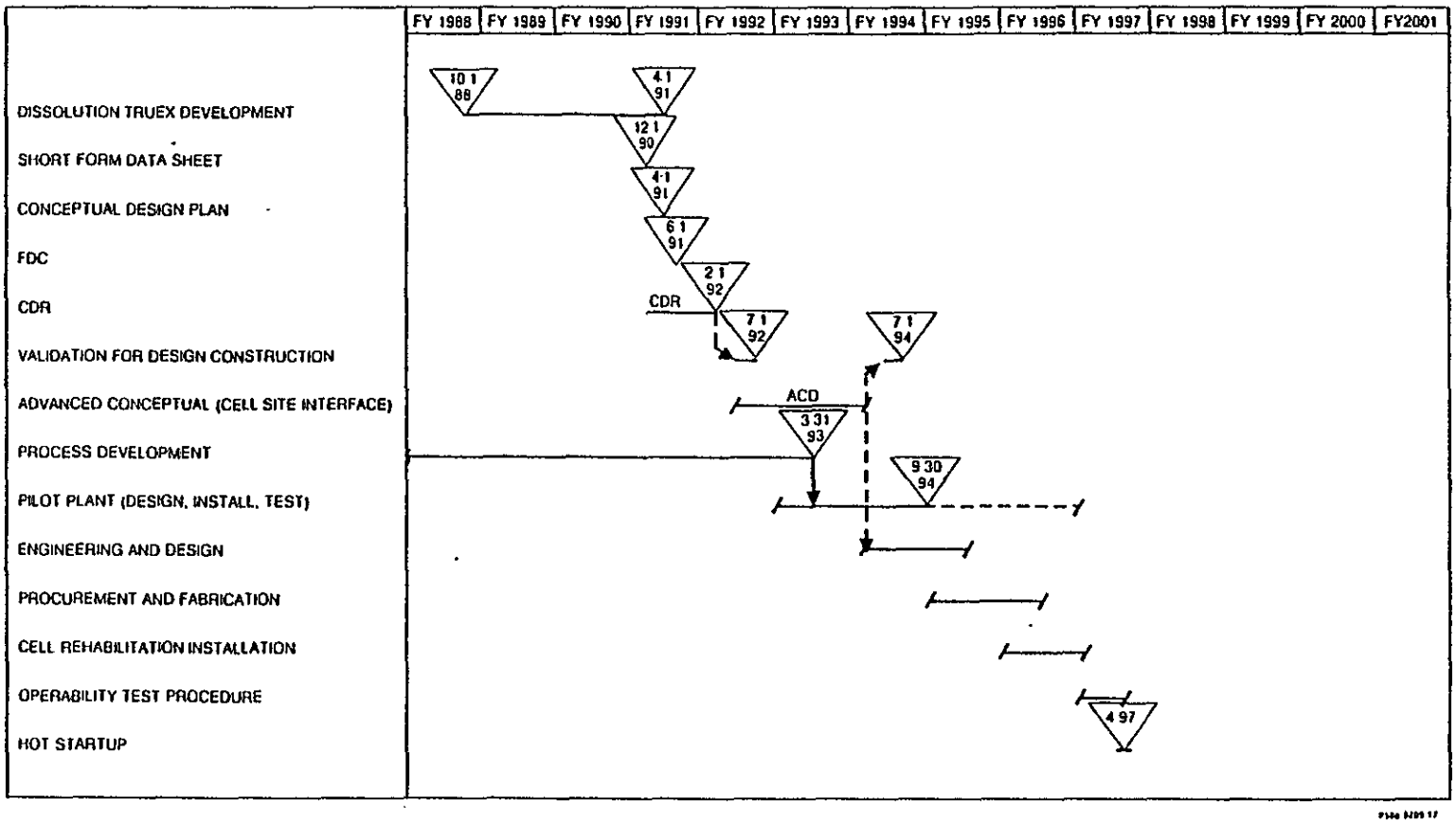

Figure 5-3. B Plant or PUREX Pretreatment Facility Schedule TRUEX Implemented in FY 1997.

in Figure 5-4. The schedule allows for "hot startup" in January 2001. A 1994 congressional Line Item is required to support this implementation schedule.

5.2.3 Expanded Hanford Waste Vitrification Plant

The baseline design for the HWVP is defined in the Reference Conceptual Design Report (Westinghouse 1987). Incorporation of waste pretreatment capabilities in the HWVP would result in extension of existing canyon and operating galleries by approximately 55 m (180 ft) through use of two parallel 6.1 m (20 ft) wide cells. Existing cell features and equipment arrangements for the original HWVP mission are unchanged. An addition of this magnitude affects several structured features (HVAC, utilities, etc.). Several existing HWVP features (e.g., canyon crane) can be shared to adequately serve both the pretreatment and vitrification cell equipment. The estimated capital cost in FY 1988 dollars for adding pretreatment capabilities to the HWVP is $162 million (Appendix E). A general description and proposed layout of the facility is also provided in Appendix E.

This study assumes that a decision is made to change the existing HWVP preliminary design prior to beginning detailed design in FY 1990. The cost for implementing a change in the HWVP design is estimated at $7 million. Preliminary design for the vitrification portion of the dual facility could be completed within 6 mo of the original schedule. Hot startup of the facility would be January 2000. Much larger funding impacts would result if a decision to change the design was made after the start of detailed design. In reality, a preliminary decision to fund an assessment of the change would need to be made by March 1989. Figure 5-5 shows the proposed schedule for implementation of the expanded HWVP facility.

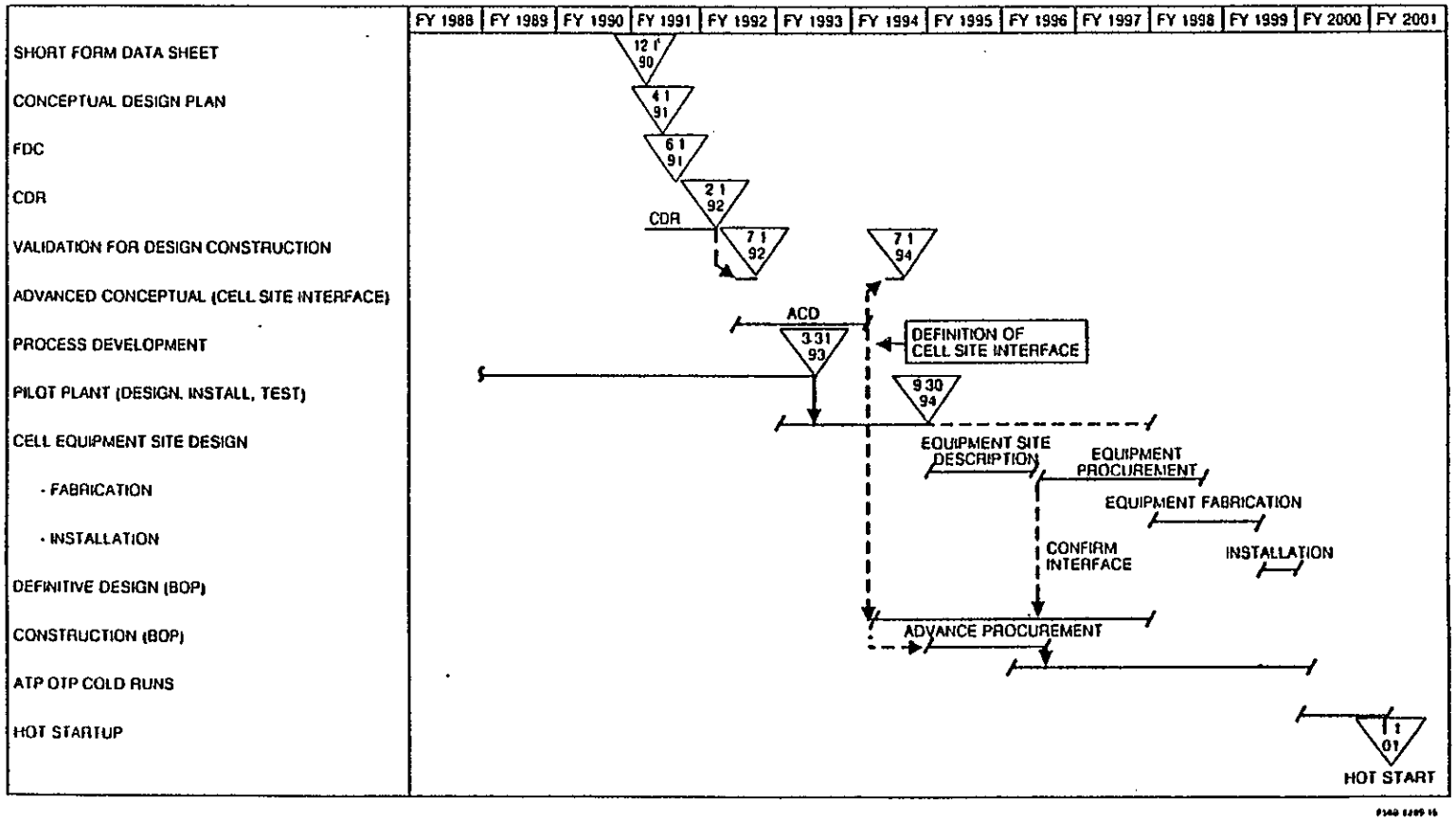

Figure 5-4. Stand-Alone Pretreatment Facility Schedule (1994 Line Item).

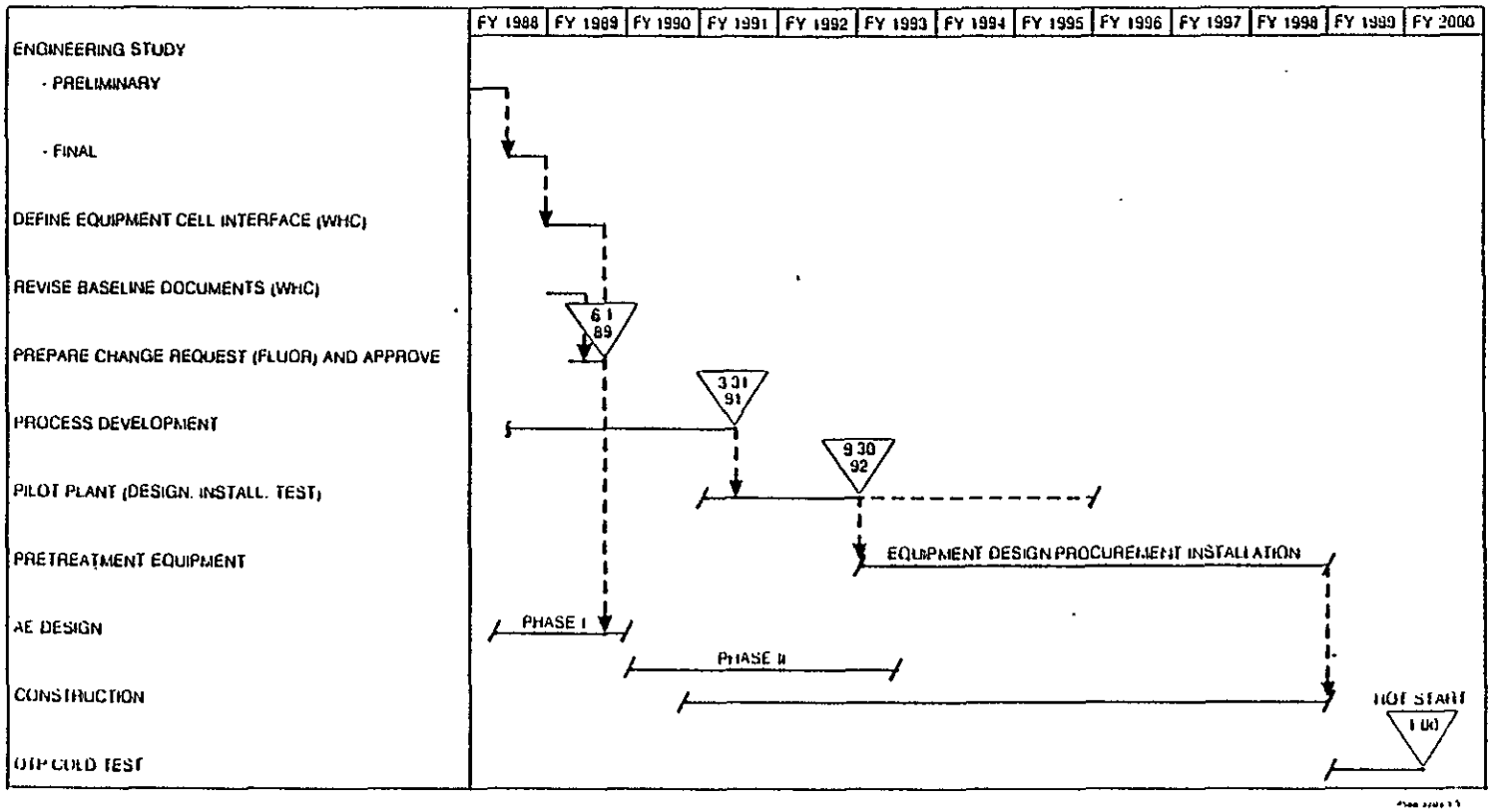

Figure 5-5. Proposed Schedule for Hanford Waste Vitrification Plant Expansion.

5.2.4 PUREX Facility

The recent decision to place N Reactor in cold standby status may increase the viability of employing PUREX for DST and SST waste processing because the production mission would be completed earlier than previously assumed. Based on current information, sufficient space is available in PUREX for the equipment required to process all DST wastes at rates comparable to those for the B Plant facility (Jacobs 1988).

A number of general concerns for using the PUREX facility for DST and SST waste pretreatment have been identified. They include the following:

- With N Reactor in cold standby status, the PUREX Plant would also have to be maintained in cold standby status and thus unavailable for waste pretreatment until N Reactor status is changed to shutdown. Also, if additional production missions are reestablished in PUREX, the use of this facility for waste pretreatment would be unlikely.

- Availability of tank farm transfer routes may affect equipment layouts in PUREX and this must be better defined. Costs to provide new transfer routes may be a significant fraction of the total waste pretreatment cost for the PUREX options.

- A separate ammonia vent system may be required for both NCRW and CC processing.

- Upgrades required to address seismic concerns have not been estimated but may have a significant effect in estimating the PUREX facility option.

It is estimated that implementation of the TRUEX process and associated equipment could be completed by mid FY 1997 with a 1994 line item. A proposed schedule is shown in Figure 5-3. A preliminary estimate of upgrades required for utilization of the PUREX facility for waste pretreatment is $140 million (1988) dollars.

5.2.5 Double-Shell Tanks

The use of existing double-shell tanks for performing solid-liquid separations and sludge washing of PFP, NCRW, CC and possibly NCAW, was addressed in Section 4.0. Place (1988a) described a proposed concept. Water washing of solids could be performed in the DSTs with mixer pumps used for waste retrieval operations. The washing efficiencies would probably not be as good as smaller vessels equipped with conventional agitators, but longer contact times could be utilized to compensate. Overall, the in-tank washing process should be faster, more reliable and less costly. Corrosion to the carbon steel walls resulting from the water additions should be minimal since contact times would be relatively short. Hydroxide and nitrite ions would also be leached from the solids and should reach sufficient concentrations to meet tank farm specifications in a relatively short time period.

In-tank filtration has not been attempted in DSTs, however, the PHP filter designed for B Plant could also be adapted for tank farm use. Support equipment for the PHP filter could be trailer mounted. The support equipment would include a precoat (diatomaceous earth slurry) makeup tank and pump, an air PRV/control station or air compressor, and computer-based control instrumentation. Alternatively, filtration could be provided in B Plant using the existing PHP filter. For the process scenario where sludge washing is performed on all waste (i.e., no TRUEX process) the TRU content in CC must be reduced to LLW levels using a complexant destruction (CD) process (see Section 4.1.5). Complexant destruction could be performed in B Plant, or alternatively, it may be feasible to perform CD directly in a DST; e.g., ozone could be bubbled into the tank waste by mounting ozone injection units onto the tank risers and supplied with electrically powered ozone generators located at grade. Alternative methods, such as thermal decomposition or photolysis, could be considered. Additional development work would be required to identify candidate methods and perform appropriate development work.

5.2.6 Role of the AR Vault

The 244-AR Vault facility is presently being upgraded to assist the B Plant in its mission for sludge washing of NCAW. The cost for these upgrades is approximately 5 million dollars. The AR Vault will provide lag storage and cooling of NCAW. If required, sludge washing and solids-liquid separation of NCAW could possibly be performed in the AR Vault rather than in DSTs, with little or no additional upgrades. Again, the feasibility of using DSTs or the AR Vault for NCAW sludge washing must be verified by an engineering study and safety analysis.

The stainless steel tanks in the AR Vault were utilized in the 1960s and 1970s for dissolution of high-heat-producing sludges, with subsequent removal of ^{90}Sr at the B Plant facility (Rasmussen 1980). Because of the age and condition of the existing dissolution tanks and the uncertainty of providing additional long-term dissolution capabilities, the use of the AR Vault for dissolving existing tank sludges prior to TRUEX processing is not addressed in this report.

5.3 COST COMPARISON OF FACILITY OPTIONS

Costs were estimated for conducting the feed pretreatment operations for each candidate waste in B Plant, the PUREX facility, a new stand-alone pretreatment facility, and an expanded HWVP. The cost for each alternative was estimated in constant FY 1988 dollars. The total program costs were used; i.e., costs for capital construction and/or upgrade of the facility, costs for waste treatment and vitrification operations and costs for disposal in a HLW repository. Costs judged to be minor or that are common to all of the alternatives were excluded from the analysis (e.g., costs for monitoring, and interim operations). Wherever applicable, existing construction project cost estimates were utilized. The cost bases and assumptions used in this study for estimating the operational and capital expenditures for the different facilities are shown in Appendix B. Appendix B also provides detailed backup to the costs.

Table 5-2 summarizes the costs for the facility options for pretreatment of DST waste using the TRUEX process, or combined sludge washing and TRUEX processing. Table 5-3 summarizes the corresponding operating times for the pretreatment facilities and the HWVP.

The mission costs for treatment of DST wastes to support a 100 kg/h melter do not differ significantly for the different facility options.* For each of the four process scenarios in Table 5-2 the total disposal mission costs for using an expanded HWVP facility are approximately the same as those for using the B Plant facility. The mission costs for using the PUREX facility or new stand-alone facility are approximately $50 million and $100 million higher, respectively, than those for using B Plant. The higher cost for use of a new stand-alone facility is attributed primarily to increased costs from maintaining the HWVP in standby status since the new pretreatment facility would not begin operations until 1.5 yr after the HWVP is scheduled to start. Alternatively, the HWVP could delay its scheduled startup. Other important factors in addition to costs that must be considered when comparing the facility options are addressed in Section 5.4.

The results shown in Table 5-2 indicate that a marked reduction in waste treatment costs result for the pretreatment facility options if the HWVP vitrifies DST waste using a 100 kg/h melter rather than a 45 kg/h melter. The cost reductions result primarily from significantly reducing the vitrification operating times (Table 5-3). Thus, expansion of the B Plant upgrade to include increased sludge dissolution rates (Table 5-2) could potentially reduce operational costs by as much as $250 million if the pretreated wastes were vitrified using the 100 kg/h melter. These cost savings would be achieved, even though some HWVP vitrification standby time occurs (see Figures 5-6 and 5-7). Again, however, the capability of modifying B Plant to include the expanded dissolution capabilities appears

*The costs in Table 5-2 for alternate facilities to B Plant include utilization of B Plant for demonstrating sludge washing and/or sludge dissolution and for generating sufficient pretreated waste to support Waste Form Qualification (WFQ) efforts (Appendix B).

Table 5-2. Cost Comparison of Facility Options--Pretreatment of Double-Shell Tank Waste.

Process scenario	Facility option - millions fiscal year 1988 dollars[a]				
	B Plant[b]		Expanded HWVP[c]	New stand-alone[c]	PUREX
	45 kg/h	100 kg/h			
1. Sludge wash NCAW in B Plant; TRUEX remaining waste	3,400[d]	3,150	3,000	3,150	--
2. Sludge wash NCAW in DST; TRUEX remaining waste	--	2,900	2,850	3,000	2,950
3. Sludge wash PFP in DST[e]; TRUEX remaining waste	--	2,850	2,850	3,000	2,900
4. TRUEX process all waste	--	2,750	2,750	2,800	2,800

NOTE: Costs include all costs for technology development, retrieval, pretreatment, processing, and disposal. HWVP costs escalated to midpoint of construction; otherwise, all costs are FY 1988 dollars.

[a]Rounded to nearest 50 million dollars.

[b]B Plant costs reflect two different sludge dissolution scenarios: (1) DST dissolution capacity to support 45 kg/h melter (2) increased dissolution capacity and 100 kg/h melter.

[c]Double-Shell Tank waste dissolution capacity to support continuous operation of HWVP at 100 kg/h.

[d]Current baseline plan.

[e]Could substitute NCRW for PFP.

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Table 5-3. Facility Operating Times--Double-Shell Tank Waste Pretreatment.

Process scenario	Canisters of glass	Facility operating time (yr)[a]			
		B Plant	PUREX	Stand alone	Expanded HWVP
1. Sludge wash NCAW in B Plant; TRUEX remainder Baseline - 45 kg/h melter	1,560	14.5 (14)	--	--	--
Enhanced - 100 kg/h melter	1,560	10.5 (8)	8[b](6)	8[b](8)	8[b](6)
2. Sludge wash NCAW in DST; TRUEX remainder	1,560	6 (5)	4 (5)	4 (7)	4 (5)
3. Sludge wash PFP in DST; TRUEX remainder	1,500	6 (5)	4 (5)	4 (7)	4 (5)
4. TRUEX all DST waste	1,200	7 (4)	5 (4)	5 (4)	5 (4)

[a]HWVP vitrification operating times are shown in parenthesis - except for baseline case, throughputs are for 100 kg/h melter.

[b]Includes B Plant operating time for washing NCAW sludge.

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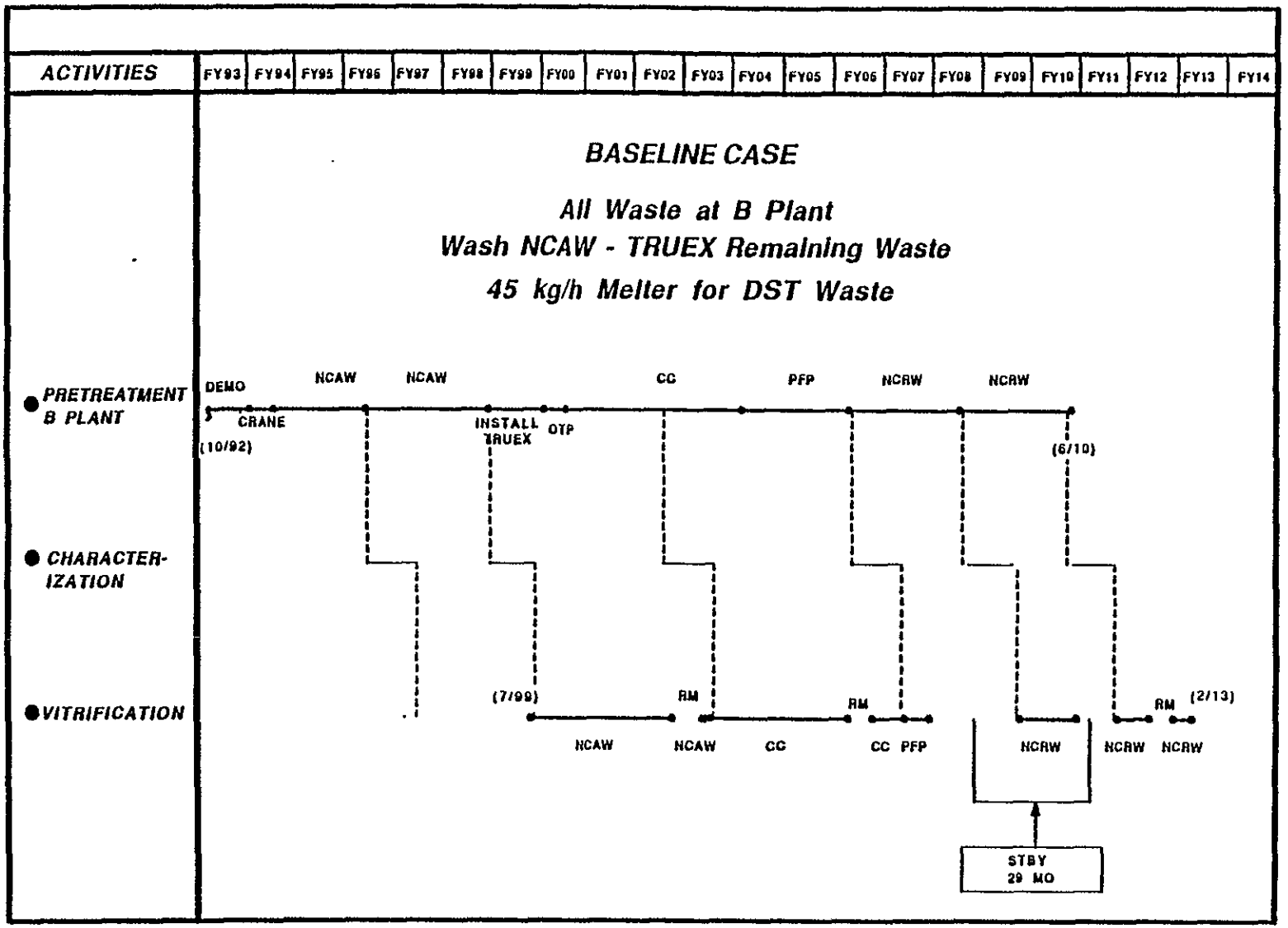
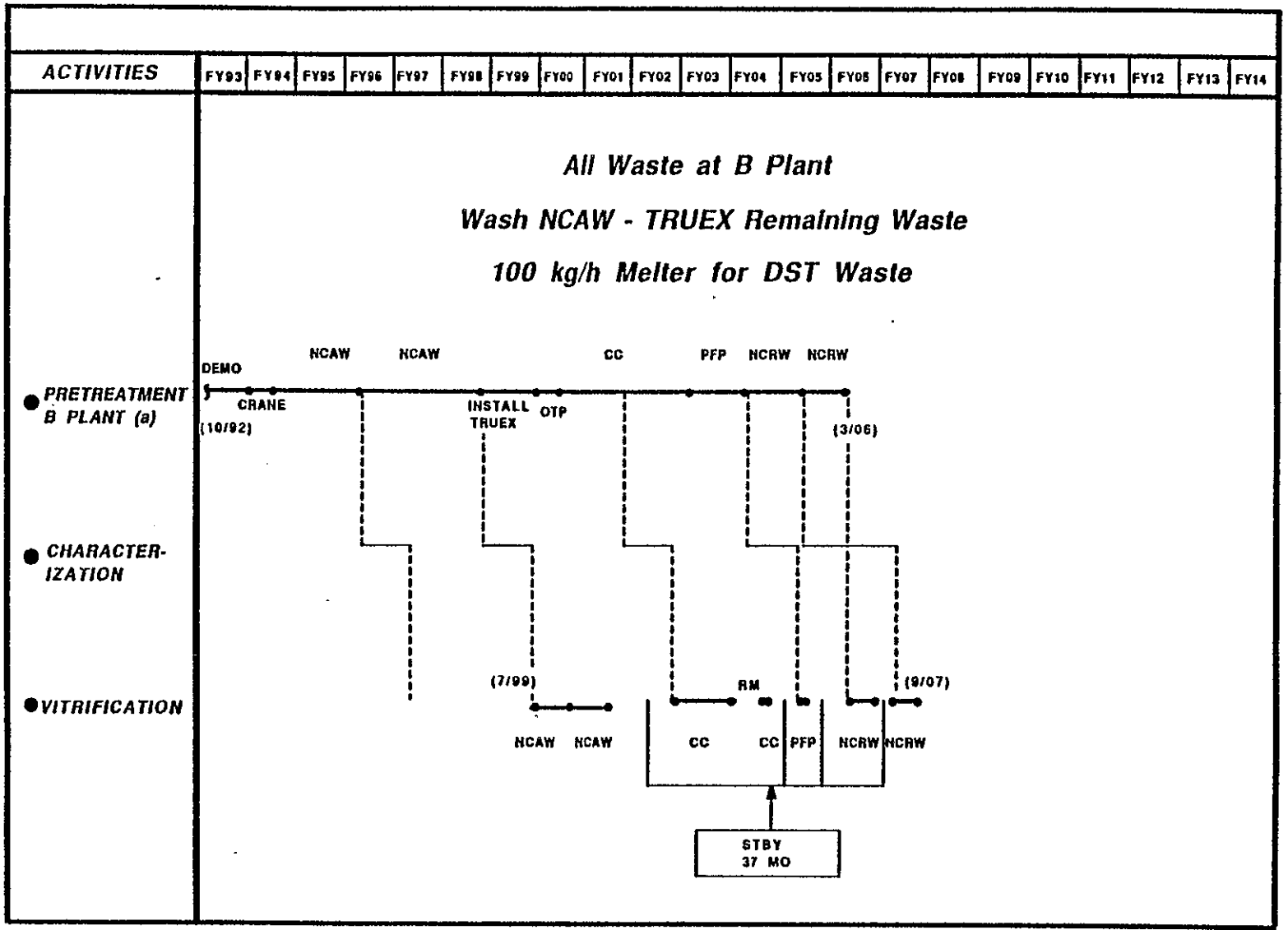


Figure 5-6. Current Baseline B Plant Processing Schedule - Wash NCAW, TRUEX Remaining, 45 kg/h Melter.



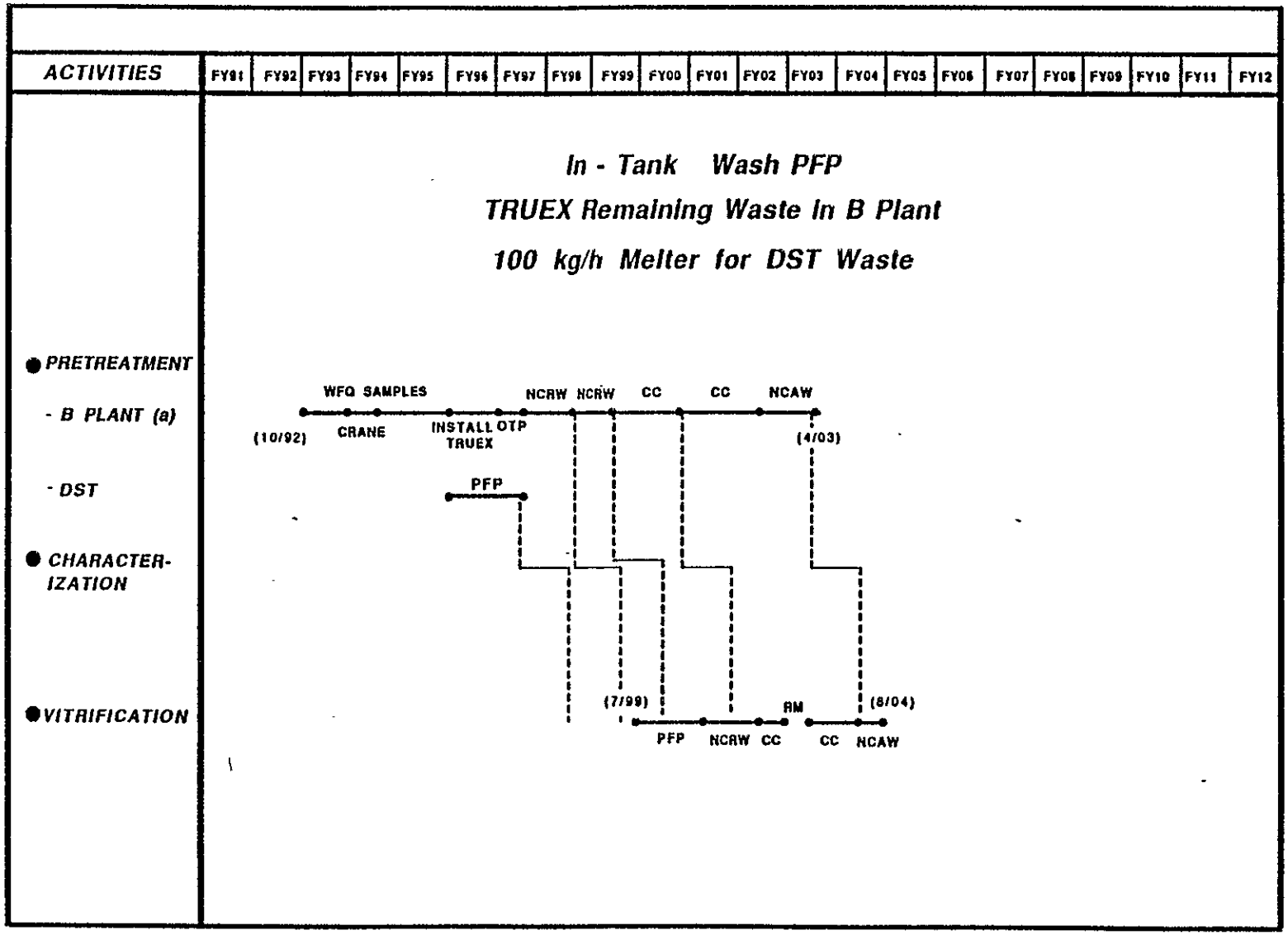
(a) Assumes additional sludge dissolution capacity at B Plant to support 100 kg/h melter

Figure 5-7. B Plant Processing Schedule-Wash NCAW, TRUEX Remaining, 100 kg/h Melter.

feasible (Place 1988b), but further evaluations need to be performed to verify this assumption. The same potential for expanding dissolution capability exists for an upgraded PUREX facility.

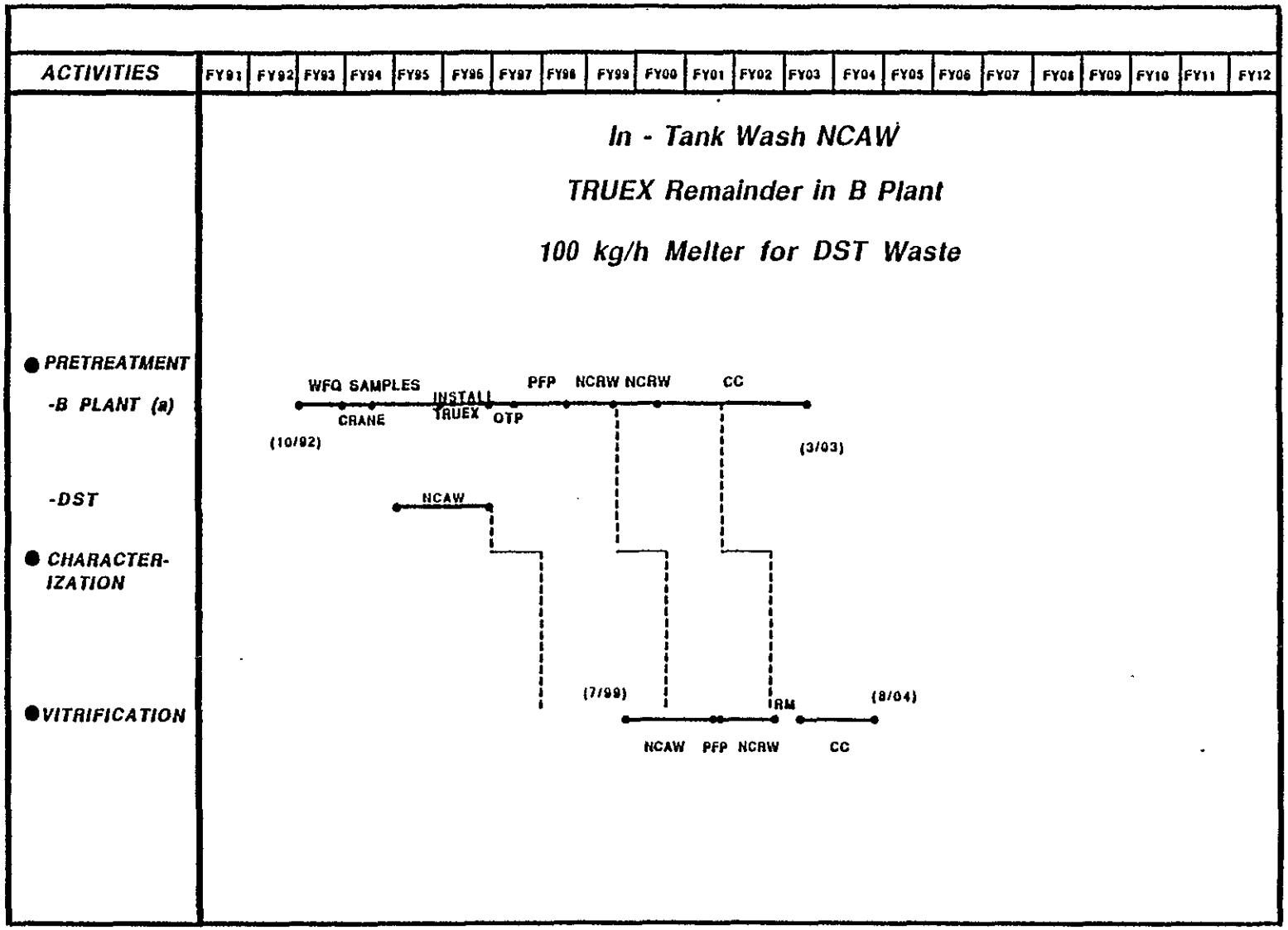
Table 5-2 also shows a definite cost advantage for washing either PFP or NCAW sludge in a DST with TRUEX processing of the remaining waste instead of the current plan of washing NCAW in B Plant with TRUEX processing of the remaining waste (Figures 5-8 and 5-9). The operational and capital expenditures (as well as the time cycles, Table 5-3) required for in-tank washing are significantly less than for washing in B Plant. The costs for these options are $150 to $300 million less than for sludge washing NCAW at B Plant. This is exemplified by comparison of Figures 5-7 with Figures 5-8 and 5-9 which demonstrates the reduced pretreatment operational requirements for the B Plant facility. In-tank washing of PFP waste or NCAW provides feedstock to the HWVP in parallel with B Plant TRUEX pretreatment. The HWVP vitrification standby is thus eliminated, allowing continuous HWVP operations and earlier completion of the vitrification mission.

The cost for the in-tank PFP washing option is slightly lower (approximately $50 million) than the NCAW in-tank washing option since 60 fewer canister of glass are produced (Table 5-3). However, washing PFP in a DST with TRUEX processing of the remaining DST waste requires use of the TRUEX process on dissolved NCAW sludges. The TRUEX processing of NCAW will result in a high concentration of ^{90}Sr to grout. To reduce the heat loading and activity level in grout, removal of ^{90}Sr from the acidic TRUEX raffinate is required (see Section 4.1.4). To date, ^{90}Sr removal methods with sufficient removal efficiencies necessary to make the TRUEX process adaptable for NCAW have not been developed (see Technical Issues, Section 7.0). It is uncertain that adequate ^{90}Sr removal technology can be developed soon enough to implement the process in the pretreatment facility. Thus, assuming that washing NCAW sludge in a DST can be shown to be feasible, the option of washing NCAW in a DST with TRUEX processing of the remaining waste is favored over the in-tank PFP washing option.



(a) Assumes additional sludge dissolution capacity at B Plant to support 100 kg/h melter

Figure 5-8. B Plant Processing Schedule - In-Tank Wash PFP TRUEX Remaining Waste.



(a) Assumes additional sludge dissolution capacity at B Plant to support 100 kg/h melter

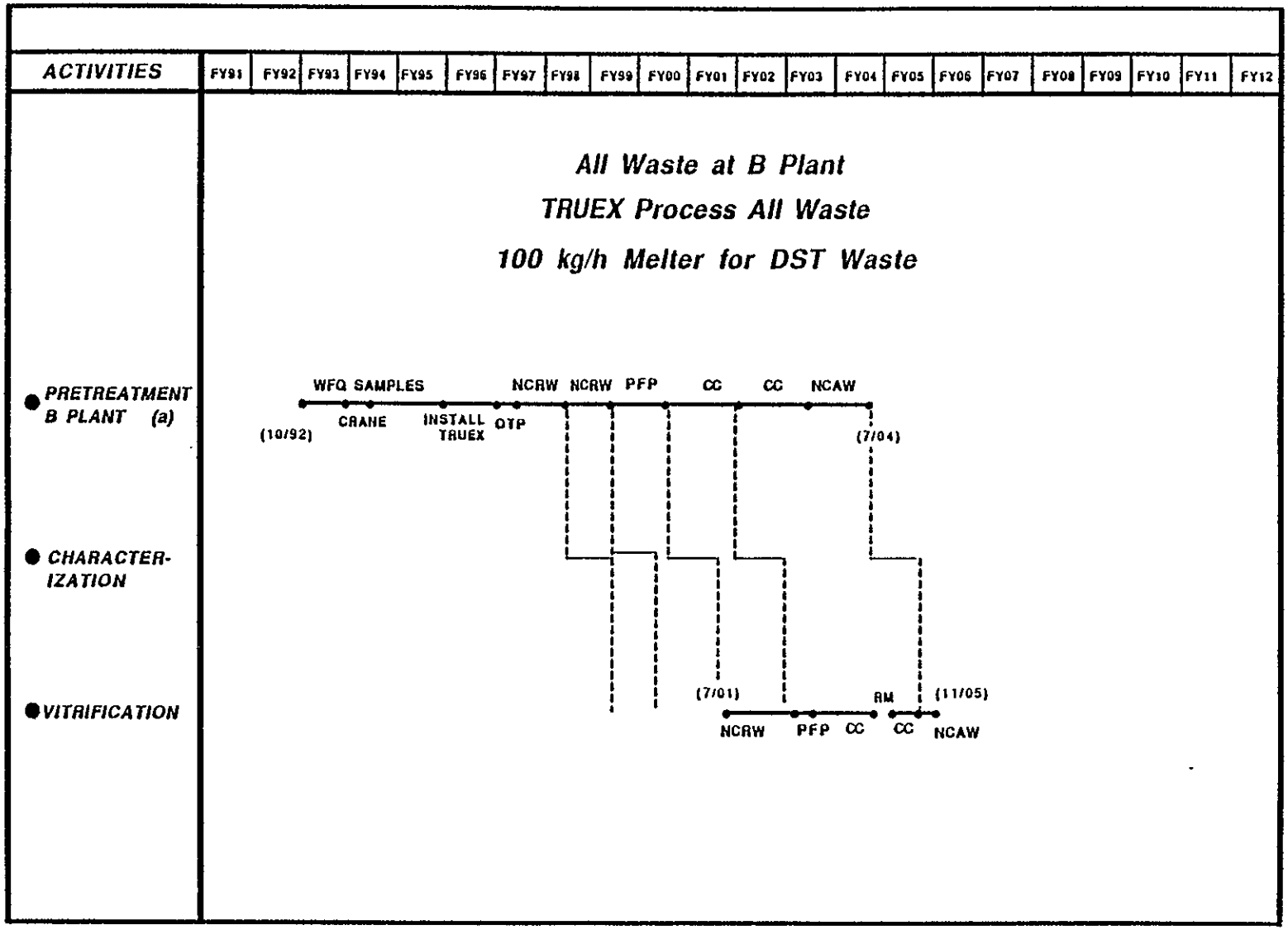
Figure 5-9. B Plant Processing Schedule - In-Tank Wash NCAW; Remaining Waste.

Table 5-2 shows that the lowest mission costs are achieved by treating all DST wastes using the TRUEX process. Processing all DST waste using the TRUEX process saves $350 to 400 million compared to the current plan of sludge washing NCAW in B Plant and using the TRUEX process in B Plant for the remaining wastes. The major cost savings for the all TRUEX option result from reduced repository costs, and the reduced B Plant operational costs required to apply the TRUEX process to NCAW sludge rather than sludge washing of NCAW at B Plant (Figure 5-10). This all-TRUEX option is also approximately $150 million less expensive than washing NCAW in-tank with TRUEX processing of the remaining waste. Again, some risk is involved with development and implementation of a ^{90}Sr removal method required for NCAW supernatant in the all TRUEX option.

Table 5-4 shows the costs for facility options involving only sludge washing (i.e., no TRUEX Process). The costs in Table 5-4 verify the observations in Section 4.0, i.e., all sludge washing options are significantly costlier than pretreatment options that utilize the TRUEX process. Figures 5-11, 5-12, and 5-13 illustrate the sludge washing facility processing scenarios described in Table 5-4. As indicated in Table 5-4 the costs for sludge washing all wastes can be reduced significantly by performing most or all of the pretreatment operations in DSTs rather than utilizing the B Plant facility. Thus, the costs for washing NCAW, PFP, NCRW and CC sludges in DSTs and performing complexant destruction in a DST (see Section 5.2.5) are approximately equivalent to those for the current baseline plan (i.e., $3.4 billion). For the $3.4 billion sludge washing case, an allowance of $50 million is included for an add-on to the HWVP for removing ^{137}Cs from NCAW supernatant. For the other sludge washing cases listed in Table 5-4, removal of ^{137}Cs from NCAW supernatant is performed at the B Plant facility.

5.4 OTHER CONSIDERATIONS

In addition to the costs required for treatment of Hanford tank wastes for final disposal operations, other important factors (schedule considerations, regulatory requirements, and the potential retrieval of SST wastes) must also be considered when comparing the facility options.



(a) Assumes additional sludge dissolution capacity at B Plant to support 100 kg/h melter

Figure 5-10. B Plant Processing Schedule-TRUEX Process All Waste.

Table 5-4. Cost Comparison for Sludge Washing (no TRUEX Process) Scenarios.

Process/facility scenario	Millions Fiscal Year 1988 dollars
1. Sludge wash NCAW in B Plant; complexant destruction CC in B Plant; sludge wash remaining waste in DST	3,800
2. Sludge wash all waste in DST; complexant destruction CC in B Plant	3,700
3. Sludge wash all waste in DST; complexant destruction CC in DST[a,b]	3,400

[a]See Section 5.2.5.

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[b]For this option an allowance of $50 million is provided for an add-on to the HWVP for removal of ^{137}Cs from NCAW supernatant.

5.4.1 Ability to Support Scheduled Startup of Vitrification Operations

With one exception, all pretreatment process and facility options where NCAW sludge is washed at B Plant, or where NCAW sludge or PFP sludge is washed in a DST will support startup of vitrification on the scheduled July 1999 date. Use of an expanded HWVP facility would likely delay vitrification several months because of the change required to incorporate pretreatment capabilities into the existing HWVP design (Section 5.2.3). A new stand-alone facility would support 1999 startup of vitrification but some standby time would result at the HWVP since the new facility could not begin pretreatment operations until FY 2001.

The pretreatment process and facility options where NCAW sludge is washed in B Plant, or where NCAW or PFP sludge is washed in a DST will also support an accelerated vitrification date (i.e., earlier than July 1999). However, the vitrification completion date could not be accelerated. For these cases the total operating time (and cost) for HWVP vitrification operations would increase due to increased standby periods. Again, it is unlikely that the expanded HWVP could provide early startup of vitrification.

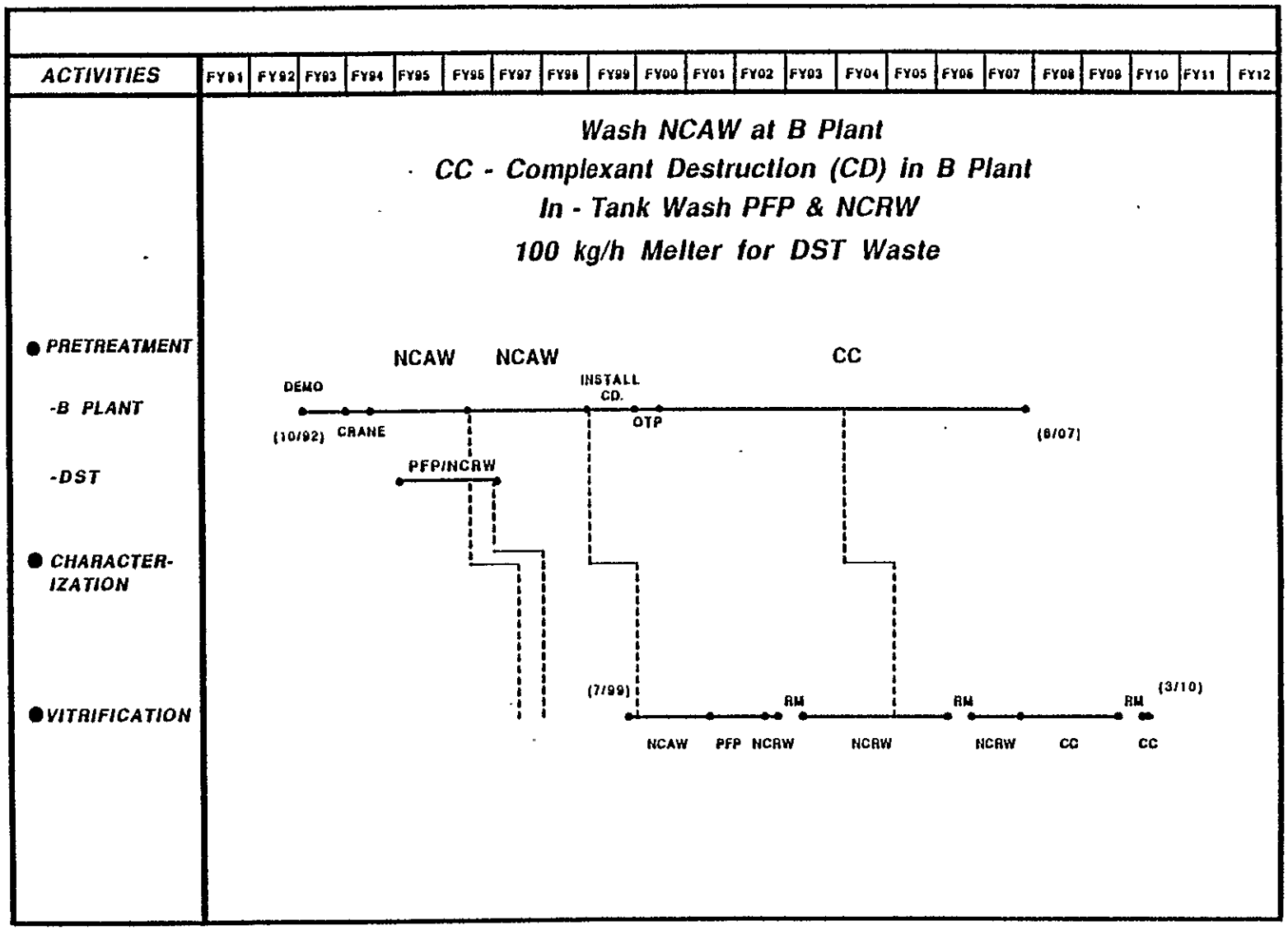


Figure 5-11. Processing Schedule - Sludge Wash NCAW in B Plant; Sludge Wash Remaining Waste in DST.

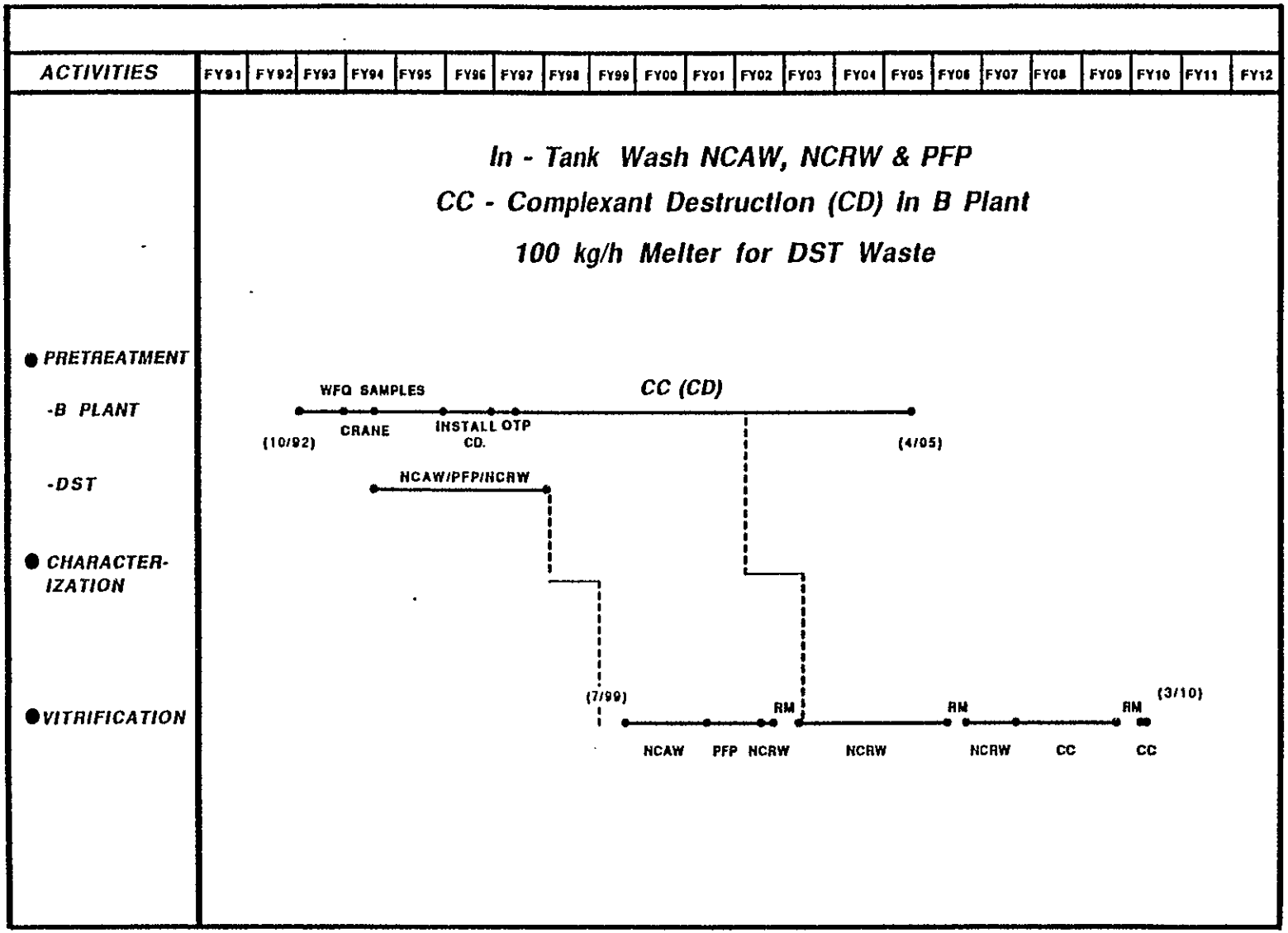


Figure 5-12. Processing Schedule - Sludge Wash All Waste in DST; Complexant Destruction CC in B Plant.

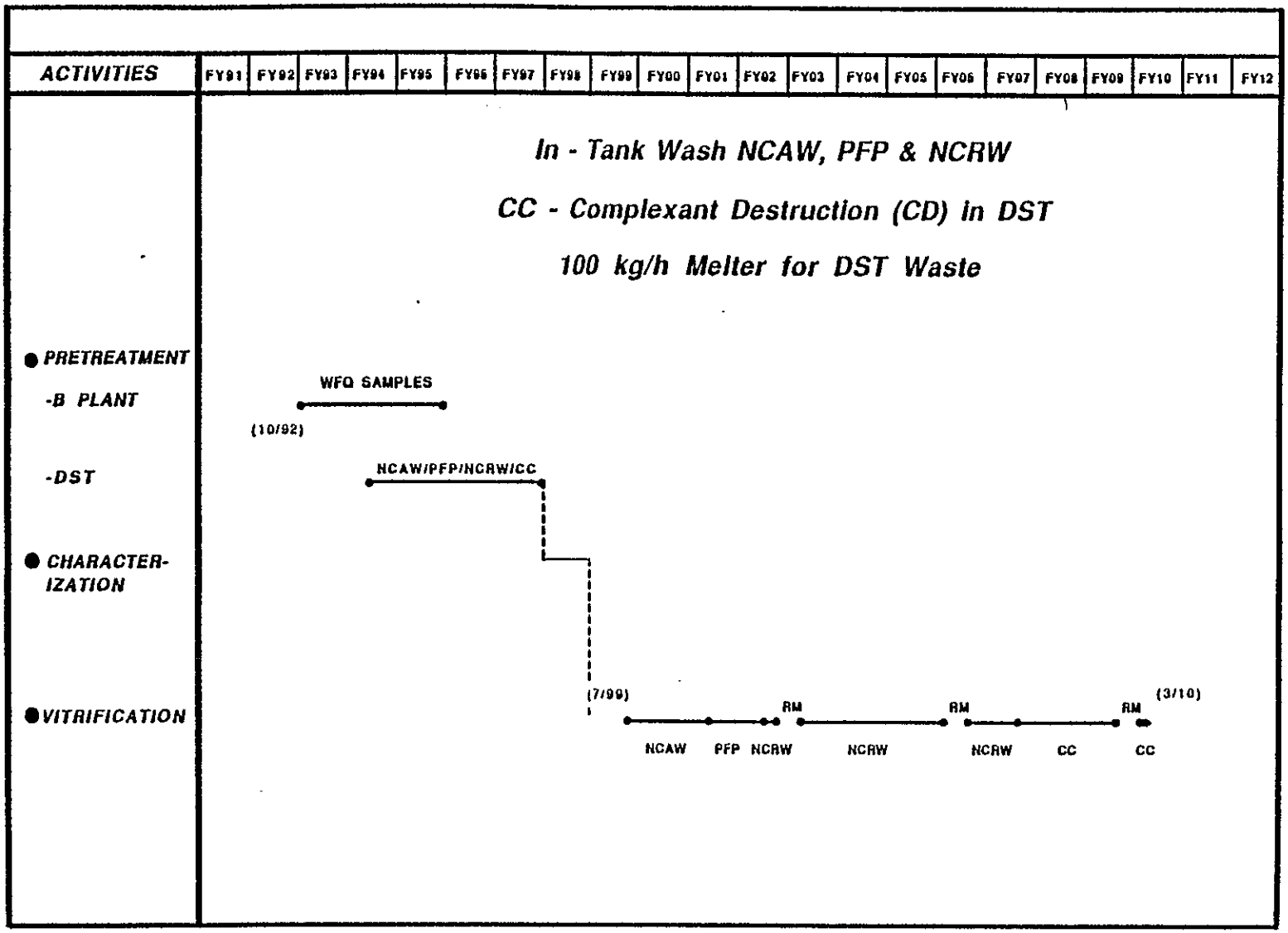


Figure 5-13. Processing Schedule - Sludge Wash All Waste in DST; Complexant Destruction CC in DST.

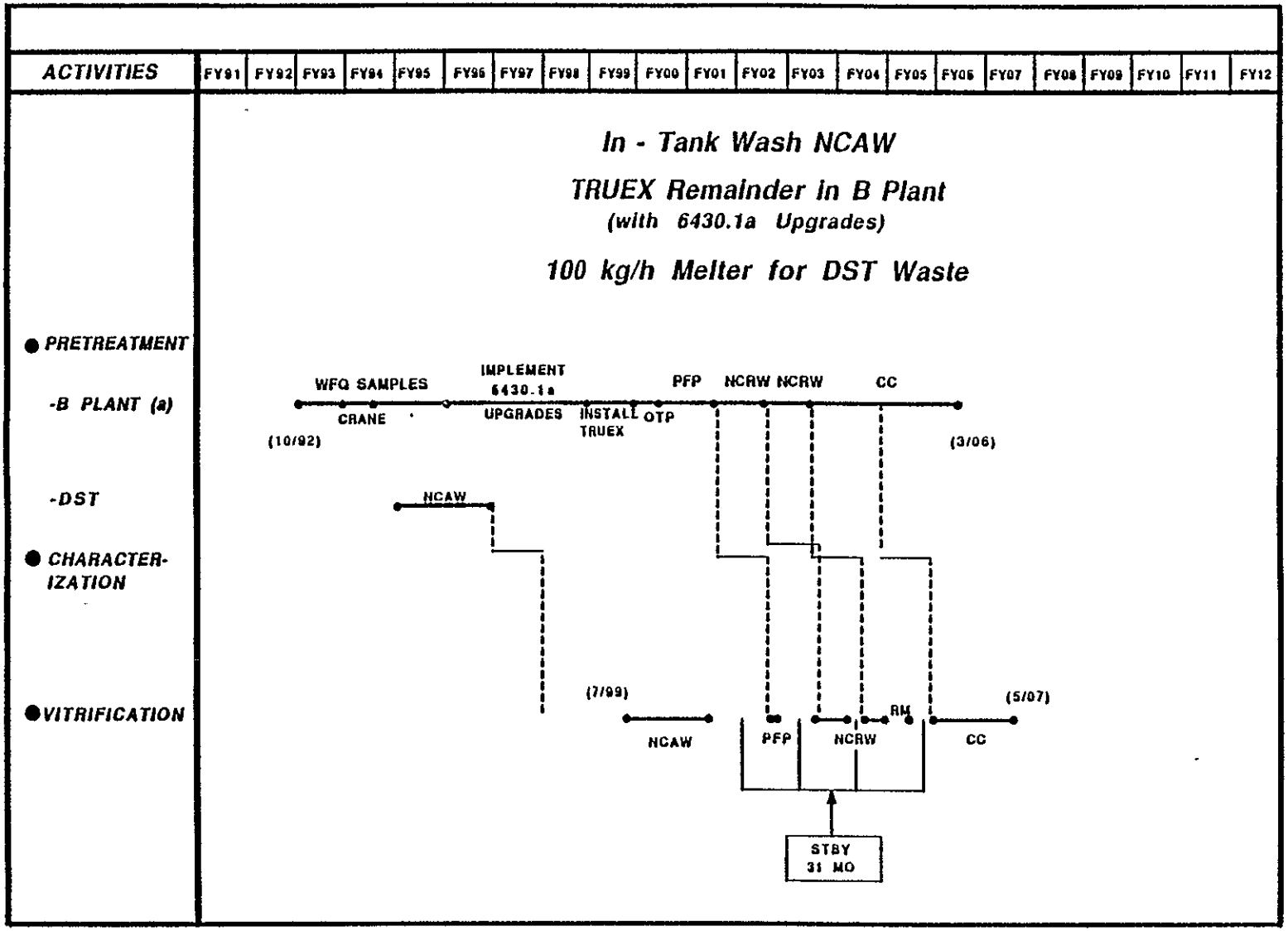
The option where all DST waste is treated using the TRUEX process could support the 1999 vitrification startup for the B Plant and PUREX facilities. Treating all DST waste with the TRUEX process in the expanded HWVP or newstand-alone facility would delay vitrification start until FY 2002 or later. The TRUEX process would not start until FY 2000 or FY 2001 for the expanded HWVP and new stand-alone facilities, respectively.

5.4.2 Ability to Comply with Evolving Changes to Orders and Regulations

Evolving changes to applicable orders and regulations create potential impacts on requirements for upgrading and operating existing processing facilities. The current B Plant Safety Analysis Report (SAR) (Sewell 1985) concludes that there are no credible accidents that result in exceeding the offsite limits. Ongoing upgrades at B Plant will provide compliance with existing regulations for the NCAW pretreatment mission. In particular, new standards and regulations for management and control of hazardous wastes and liquid effluents will be implemented.

The ability to extend the B Plant or PUREX Plant pretreatment mission to SST wastes is uncertain, however. Although the upgrades presently being implemented in B Plant will provide conformance with existing state and federal laws, incorporation of some new requirements may be necessary to conform with DOE Order 6430.1A, particularly if operations extend beyond DST waste.

Compliance with DOE Order 6430.1A is required for new facilities (e.g., a new stand-alone or expanded HWVP). Compliance for existing facilities is voluntary and the degree of compliance is determined by the Department of Energy. Upgrades to B Plant to full 6430.1A compliance could cost between $100 million and $250 million dollars (Appendix G) and an estimated 3 to 5 yr would be required to implement the upgrades. Figure 5-14 illustrates the schedule of full 6430.1A compliance for the processing scenario where NCAW is washed in a DST and the TRUEX process is used for the remaining DST waste.



(a) Assumes additional sludge dissolution capacity at B Plant to support 100 kg/h melter

Figure 5-14. Impact of 6430-1A Upgrades to Waste Pretreatment Schedule.

The total upgrade cost and schedule impacts would increase the cost of this case by approximately $400 million. This impact may not be cost effective for only 6 yr operations of B Plant. If full compliance with 6430.1A was determined to be required for B Plant, the lowest cost options that would meet 6430.1A compliance are a new stand-alone facility or the expanded HWVP. However, if the decision that B Plant must comply with 6430.1A was delayed beyond March 1989, a cost increase for the expanded HWVP would result since detailed design for the HWVP would be in progress (see Section 5.2.3).*

5.4.3 Schedule Constraints

Expanding the HWVP for waste pretreatment would require an increase in HWVP program costs and schedule. The implementation schedule shown in Section 5.2.3 indicates that the design change to HWVP would result in an approximate 6 mo delay to startup of vitrification. With this scenario the use of the expanded HWVP would result in approximately the same cost for the DST waste disposal mission as for use of B Plant. However, this assumes that a commitment is made before March 1989 to modify the HWVP design since detailed design will begin at this time. Further delays would result in increased cost impacts. The probability of a decision being made within 6 mo of issuance of this report with no net cost incentive is low.

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*An assessment of the viability of B Plant to perform the waste management mission was summarized in WHC 1989, subsequent to preparation of this report. The areas investigated included (1) an evaluation of compliance with DOE, Washington State, and federal regulations; (2) a preliminary accident analysis; (3) a natural forces evaluation to determine the facility structural response to a seismic event; and (4) a life-extension analysis to examine the facility for aging effects. No issues were found that would prevent B Plant from completing the pretreatment mission. The viability evaluations identified an additional $14 million in upgrade required to bring the facility to a condition that complies with DOE design criteria, safety, and environmental orders.

A new stand-alone facility would not be operational before FY 2001. This would require a decision by October 1990 for a 1994 line item. For the process scenario evaluated with this schedule, use of a new stand-alone facility would result in undesirable standby of the HWVP and would cost approximately $100 million more than comparable waste treatment using B Plant (Section 5.3). The projected costs would increase further if a decision to build a new facility was delayed beyond 1990.

It is assumed in this report that TRUEX process could be implemented in the PUREX facility following the same schedule as for implementing TRUEX at B Plant (Section 5.2.4) and total program costs for using the PUREX facility rather than B Plant would increase approximately $50 million.

As noted in Section 5.3, if additional production missions were established for the PUREX facility, or if the presently scheduled fuels processing mission was delayed the TRUEX process implementation schedule could not be met and feed to the vitrification facility would be delayed. Additionally, the availability of the PUREX facility for pretreatment is contingent upon changing the N Reactor cold standby status to shutdown status.

5.4.4 Effect of Decision to Recover Single Shell Tank Wastes

The HWVP is scoped to accommodate all single-shell tank wastes pending the waste recovery decision as stated by the Record of Decision in the Hanford Defense Waste - Environmental Impact Statement. A comparison of sludge washing and TRUEX processes for pretreatment of waste in all 149 tanks is shown in Table 5-5. The data in Table 5-5 are extracted from a study on SST waste processing alternatives by Higley and Schulz (1988).

Table 5-5. Single-Shell Tank Waste Pretreatment Processes.

Process	Increment over DST only[a]		
	Glass canisters	HWVP operation (yr)	Costs (billions FY 1988 $)
Sludge washing	23,400	74	15.5
TRUEX	7,600	24	6.1

[a]149 single-shell tanks.

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As indicated by Table 5-5, completion of all SST waste vitrification within the HWVP operating life requires that the TRUEX process or an equivalent process is used that segregates SST wastes into a low volume HLW fraction and a large volume LLW fraction. The Higley and Schulz (1988) study makes the same conclusion if only the 75 SSTs containing waste with concentrations greater than 100 nCi/g of transuranic elements (TRU classification) are retrieved. A comparison of operating times and costs for DST and DST plus SST waste processing missions using the TRUEX process is summarized in Table 5-6. The operation of a pretreatment facility for 20 to 30 yr without full 6430.1A compliance is deemed unlikely. The decision to retrieve a significant portion of the Hanford SST wastes would result in recommending construction of a new stand-alone pretreatment facility as (1) being more cost effective than upgrading B Plant to full 6430.1A compliance and (2) having greater public acceptability than long term operation of a facility that would be 80 yr old before completion of the pretreatment mission.

Table 5-6. Impact of Single-Shell Tank Retrieval Decision on Double-Shell Tank Waste Processing Mission.

Waste processed	Glass canisters[c]	Operation (yr)	Total cost (billions FY 1988 $)
DST	1,560	6	2.9
DST + TRU SSTs[a]	6,800	22	7.0
DST + All SSTs[b]	9,200	30	9.0

[a]75 SSTs containing greater than 100 nCi/g transuranic elements.
[b]149 SSTs.
[c]Sludge washing NCAW sludge, TRUEX for all remaining waste.

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Secondary impacts on the DST program as a result of making a SST retrieval decision are:

- If a decision is made prior to 1994 to retrieve SST wastes, there may be cost savings by accelerating the new stand-alone facility startup and processing a portion of the DST wastes in the new facility in lieu of B Plant.

- The decision to produce grout feed with radionuclides contents comparable to Class A LLW in conjuction with the SST waste retrieval decision would make technology development for additional radionuclide removal critical. The TRUEX process or an alternate is required for a viable SST retrieval program and current process performance is projected to be inadequate to produce radionuclide levels in grout feed comparable to Class A LLW (10 CFR 61).

- With SST waste retrieval program costs of 6 billion dollars, incentives exist to justify a significant development effort to increase the fraction of solids dissolved in the TRUEX process or to develop an alternate process that minimizes residual solids routed to HWVP for vitrification. A potential cost reduction in excess of one billion dollars for the SST retrieval program could result if technology can be developed to remove the residual aluminum and silicon solids from the TRUEX process. The aluminum and silicon in the SST waste form the predominant fraction of acid insoluble solids. These solids result in high glass volume and waste disposal costs. The aluminum and silicon in the SST waste resulted from the aluminum-silicon alloy used to bond aluminum jackets to uranium fuel used in some Hanford production reactors.

5.5 CONCLUSIONS AND RECOMMENDATIONS

It is concluded that waste pretreatment facility utilization can be optimized to significantly reduce DST waste treatment and disposal mission costs. A potential of up to $500 million cost reduction from the current baseline plan can be achieved. The costs for the preferred option can be reduced by the following actions.

- Increasing the vitrification and TRUEX process capacity--A marked reduction in waste pretreatment and vitrification operation costs result if the HWVP vitrifies all DST waste using a 100 kg/h melter rather than a 45 kg/h melter, and the throughput of the TRUEX process pretreatment facility is sized to support operation of the large capacity melter. Processing DST waste at the high throughput rate reduces mission costs up to $250 million.

- Washing NCAW in a DST rather than washing in B Plant--This facility scenario provides an additional mission cost savings of $250 million. Aged NCAW and lower decay heat in the sludge may allow the use of existing DSTs for settle-decant washing of NCAW sludge in lieu of the small 5,000 gal B Plant tanks originally specified for short cooled NCAW. The operational time and expenditures required for in-tank washing of NCAW sludge are significantly less than for washing NCAW in B Plant. In-tank washing of NCAW sludge also provides additional feedstock to be HWVP in parallel with B Plant TRUEX process pretreatment and enables continuous HWVP operations. The combination of the in-tank NCAW sludge washing with the action of increasing HWVP vitrification and B Plant TRUEX processing capacity eliminates HWVP standby time and minimizes operation costs. An engineering analysis is required to confirm the feasibility of washing NCAW sludge in a DST.

- Utilization of the B Plant facility for application of the TRUEX process to PFP, NCRW and CC--Depending on the waste processing scenario DST waste disposal costs are up to $100 million less expensive if the B Plant facility is utilized for waste pretreatment of PFP, NCRW and CC using the TRUEX process. Washing NCAW sludge in DSTs instead of B Plant requires a 3 yr acceleration of the TRUEX process installation in B Plant (1994 line item) to maximize cost savings.

The engineering and development efforts required to confirm the basis for the preferred option can be performed simultaneously with the existing program for implementing the B Plant NCAW sludge washing demonstration with minimal increase in cost. The sludge washing demonstration supports both the current baseline plan and the preferred option. Near-term B Plant program costs and schedules will not be affected.

A decision analysis is provided in Appendix D which graphically depicts on a time scale the technical and programmatic decisions required to arrive at a viable DST pretreatment system. The alternate paths through the logic tree result in the process and facility options described in this report. The logic tree identifies the technology plan required to arrive at the preferred pretreatment option and also identifies the backup options. Following are the necessary supporting engineering and development efforts that must be pursued in FY 1989 and FY 1990 to resolve the decision points and confirm the preferred option.

1. Perform preconceptual design of an increased capacity TRUEX process in B Plant as a 1994 line item.

2. Evaluate by March 1989 the impact on the HWVP project of increasing the melter throughput from 45 kg/h to 100 kg/h.

3. Evaluate the heat transfer and safety aspects of washing NCAW sludge in a DST.

4. Evaluate the implications of in-tank NCAW sludge washing on waste retrieval requirements, and on tank farm space requirements and availability.

5. Develop plans for obtaining 400 kg samples of acid washed PFP, CC, and NCRW solids in B Plant by 1996 in support of the HWVP WFQ effort.

6. Perform an engineering study to define the impact of reducing radionuclide contents in grout feed on the pretreatment and vitrification program.

7. Develop a preliminary approach for removal of selected key radionuclides from grout feed.

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6.0 COMPARISON OF DISPOSAL OPTIONS

The cost of transportation and disposal of the TRU and high-level waste fractions of processed waste streams is a potentially significant factor in selecting the preferred pretreatment option. Because of the high costs associated with disposal of waste in a high-level waste repository, there is a major incentive to reduce the number of canisters of glass sent to the repository. However, alternative disposal options, such as the WIPP, can have a marked effect on the costs for waste disposal. The projected costs for transportation and disposal of each waste type, given in this section, demonstrate the importance of these factors.

6.1 DESCRIPTION OF DISPOSAL OPTIONS

Two geologic repository disposal options for immobilized TRU solids may be possible. The alternatives addressed in this study consider disposal of TRU solids in the high-level waste repository or in the WIPP in New Mexico. The incentive for considering the latter disposal option is the significant difference in disposal costs. Disposal costs at WIPP are estimated to be approximately $33,000 per canister, including transportation, whereas the estimated costs for disposal in the high-level waste repository are $350,000 per canister (Federal Register 1987). The greatest uncertainty to the WIPP disposal option is whether all or a portion of treated PFP sludge and NCRW is acceptable at WIPP as non-high-level waste.

6.2 COSTS AND IMPACTS OF DISPOSAL ALTERNATIVES

The repository and transportation costs for both disposal options have been estimated for each waste type. In addition, disposal of a more concentrated waste-loading product in WIPP has been estimated. The costs are shown in Table 6-1; they are based on previously reported canister

Table 6-1. Comparison of Disposal Costs ($ Million).

Waste type/ pretreatment process[a]	HLW repository disposal	WIPP repository (normal waste loading)	WIPP repository (high waste loading)
NCAW-washing	170	--	--
NCAW, TRUEX	42	--	--
PFP-washing	140	13	8.3
PFP, TRUEX	35	3.3	2.1
CC-CD	300	29	18
CC, TRUEX	200	19	12
NCRW-washing	560	53	33
NCRW, TRUEX	140	13	8.3
SST-75[b], washing	5,200	490	310
SST-75[b], TRUEX	1,800	170	100
SST-149[c], wash	8,400	790	490
SST-149[c], TRUEX	2,700	250	160

[a]Pretreatment processes for each waste type are described in Section 4.0.
[b]Assumes retrieval and processing of waste from 75 SSTs.
[c]Assumes retrieval and processing of waste from 149 SSTs.

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projections for each pretreatment option and waste type. The high waste loading case assumes that a 40% waste loading (instead of 25% waste loading) is achieved for WIPP disposal. A higher waste loading reduces the repository disposal and transportation costs proportionately. The higher waste loading case is considered because WIPP disposal criteria are less stringent, removing much of the waste form quality restrictions necessary for disposal in a high-level waste repository.

Table 6-1 demonstrates the significant reduction in transportation and repository costs by applying the TRUEX process to all types of wastes. The PFP waste and NCRW have the most promise as WIPP disposal candidates. The cost projections show that more than $150 million can be saved in repository cost by sending vitrified PFP and NCRW (pretreated by the TRUEX process) to WIPP. Modification of the HWVP design or glass formulation to achieve a 40 wt% waste loading in the glass has a less pronounced effect, however, only reducing the costs by an additional $6 million.

Although CC is generally considered not to be a plausible candidate for WIPP disposal, the projected repository costs are given for CC in Table 6-1 to demonstrate the potential cost savings. Similarly, if retrieval is necessary, disposal of SST waste at WIPP is questionable, but projected costs are given for comparison.

With the repository costs established, the effect of alternative disposal options on the selection of the preferred pretreatment option for each waste type can be determined. The WIPP option could remove the incentive to process wastes qualifying for WIPP by the TRUEX process if additional processing costs outweighed the costs of vitrification and WIPP repository disposal. To determine the effect of the WIPP disposal option on the total treatment and disposal costs, a number of cases have been studied. Table 6-2 was generated using the disposal costs in Table 6-1 and the costs for pretreatment, vitrification, grouting, and miscellaneous costs presented previously.

Table 6-2. Comparisons of Total Treatment and Disposal Costs, Millions Fiscal Year 1988 Dollars.

Pretreatment option	Disposal option	Cost
Sludge wash NCAW (B Plant); TRUEX remainder in B Plant (current baseline)	a. HLW repository--1,560 cans b. WIPP, PFP, and NCRW--500 cans HLW repository, NCAW, and CC--1,060 cans	3,400 3,250
Sludge wash NCAW (B Plant); TRUEX remainder at B Plant; 100 kg/h melter	a. HLW repository--1,560 cans b. WIPP, PFP, and NCRW--500 cans HLW repository, NCAW, and CC--1,060 cans	3,150 3,000
Sludge wash NCAW in DST; TRUEX remainder B Plant	a. HLW repository--1,560 cans b. WIPP, PFP, and NCRW--500 cans HLW repository, NCAW, and CC--1,060 cans	2,900 2,750
Sludge wash PFP (in-tank); TRUEX remainder at B Plant	a. HLW repository--1,500 cans b. WIPP, PFP, and NCRW--800 cans HLW repository, NCAW, and CC--700 cans	2,850 2,600
TRUEX all DST waste at B Plant	a. HLW repository--1,200 cans b. WIPP, PFP, and NCRW--500 cans HLW repository, NCAW, and CC--700 cans	2,750 2,600
Sludge wash NCAW in B Plant; sludge wash remainder in DST	a. HLW repository--3,350 cans b. WIPP, PFP, and NCRW--2,000 cans HLW repository, NCAW, and CC--1,350 cans	3,800 3,200
Sludge wash all waste in DST; complexant destruction CC in B Plant	a. HLW repository--3,350 cans b. WIPP, PFP, and NCRW--2,000 cans HLW repository, NCAW, and CC--1,350 cans	3,700 3,100
Sludge wash all waste in DST; complexant destruction in DST	a. HLW repository--3,350 cans b. WIPP, PFP, and NCRW--2,000 cans HLW repository, NCAW, and CC--1,350 cans	3,400 2,800

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Table 6-2 shows that the disposal option can affect, at least to some degree, the selected pretreatment option for a given waste type. For instance, by implementing the WIPP disposal option for PFP waste and NCRW, the current baseline case is roughly equivalent in cost to sludge washing NCAW in B Plant, and washing remaining waste in DSTs (i.e., ~$3.2 billion). On the other hand, for wastes that are not a candidate for WIPP, such as CC and NCAW, the TRUEX process is clearly the less costly option.

6.3 SUMMARY AND OBSERVATIONS

Because of the significant cost savings, the WIPP disposal option should be actively pursued, especially for those wastes most likely to gain acceptance in WIPP, i.e., PFP waste and NCRW. However, numerous uncertainties exist, even for PFP wastes and NCRW, for gaining WIPP acceptance. Strategies must be developed to improve the likelihood of WIPP acceptance of these wastes. Evaluation of these strategies must consider the impact on the schedules of the pretreatment facility and HWVP.

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7.0 TECHNICAL ISSUES

In addition to the regulatory related issues described in Sections 5.4.2 and 5.4.4, several key technical issues which have an important bearing on both waste processes and facility options have been identified. These issues generally relate to the immediate need for characterization of the candidate waste feeds and for pretreatment process development efforts. Resolution of several of these issues must be provided on a priority basis. Several conclusions made in this report should be considered preliminary until sufficient development work required to resolve the issues has been completed.

- Can the TRUEX process be successfully applied to Hanford DST and SST waste?

  Numerous bench-scale tests have been performed in the development of the TRUEX process on simulated Current Acid Waste (CAW) and NCAW. Tests to date indicate that the TRUEX process is applicable to NCAW, as well as PFP waste, CC, NCRW, and retrieved SST waste. However, an enhanced development program is needed to define operating parameters so that adequate flowsheets can be developed to support design. Without this enhanced development program, which should include pilot and bench-scale tests with simulated and actual wastes, the ability to create LLW raffinate cannot be verified. Verification of TRUEX process capability is important to confirm the selection of the TRUEX process as the primary pretreatment option. More importantly, however, technology development is needed to support processing design, including the following:

  - The organic solvent-to-feed ratio, which determines the processing rate and size of columns or contactors

- The degree of acidification of the feed, which governs how much acid is needed

- The amounts and compositions of scrub and strip solutions.

All of these factors can affect processing cost assumptions upon which this study is based. However, none of these variables in operation are expected to affect the selection of the TRUEX process as the primary pretreatment option. Consequently, facility options are not expected to be affected.

An additional uncertainty affecting the results of this study is the influence of high concentrations of zirconium in NCRW and uranium in SST waste on TRUEX process operations. At the time of this report, tests with high concentrations of these elements have not been performed to any great extent. High concentrations of uranium can interfere with the extraction of americium into the solvent. Consequently, high organic-to-aqueous (O/A) phase ratios have been conservatively postulated to account for the uranium interference. Additional technological development on the influence of zirconium and uranium will better define the operating parameters for a more refined estimate of processing costs, equipment size, and production rates.

Although increased knowledge of TRUEX processing behavior will probably change the cost estimates in this report, subsequent sensitivity analyses are not expected to alter the preferred pretreatment or facility options.

- <u>How much sludge will dissolve and what is the impact on vitrification and grout waste forms</u>?

The most influential uncertainty associated with the TRUEX process in this study is the assumed amount of sludge that will dissolve in acid. Presently, 75% of DST sludge is assumed to dissolve in

nitric acid, and because of suspected insoluble cancrinite, 70 vol% of SST sludge is assumed to dissolve in nitric and oxalic acid. These values are based on limited laboratory data with actual and simulated waste samples. Similarly, the amount of CC solids that will dissolve in acid is uncertain. Again, based on very limited laboratory data, it is assumed in this study that CC solids do not dissolve in acid. As discussed in Section 4.0, however, 75% solids dissolution would in turn reduce the canisters of glass by 75%. Development of dissolution concepts and a better understanding of the dissolution process for each waste type will provide a much greater certainty on the processing costs for each waste type. Variation from the sludge dissolution assumptions used in this study will directly affect the number of canisters of glass that would be generated. Pretreatment facility equipment sizing and processing throughputs would be directly affected. The disposal costs for each waste type would also be altered which could in turn influence the preferred pretreatment process and facility option. Laboratory-scale tests need to be performed as soon as possible using representative waste samples to obtain dissolution data and optimize dissolution parameters.

- What is the effect of waste treatment on glass acceptability and waste form qualification?

  The projections of glass canister numbers are generally based on a 25 wt% concentration of waste oxides in the vitrified waste product. The waste loading limit for the HWVP glass melter is based on glass quality and processing limits. The preliminary process flowsheets developed for this study (flowsheets will be included in the final September 1988 report) and glass canister estimates are based on the 25 wt% waste oxide loading limit. However, waste loading limits have also been established independently for individual waste components. Plutonium Finishing Plant waste, for example, contains high concentrations of chromium. Although the combined waste loading limit for all waste oxides is 25 wt%, the present limit for Cr_2O_3, which is

based on the formation of chromium spinel crystals on the floor of the glass melter, is 0.5 wt%. These individual component processing limits can impact the acceptability of the waste feed to glass. Other wastes such as NCRW will contain high concentrations of zirconium and fluoride relative to prescribed limits. High concentrations of other refractory components in the glass could result from application of acid dissolution and the TRUEX process to the wastes. The net result is that the feed material from these wastes must be processed at less than 25 wt% waste loading. Consequently, the number of canisters could increase significantly, and HWVP processing costs and disposal costs would increase. As part of the WFQ effort, development of laboratory and bench-scale testing must be performed as soon as possible to address these impacts.

Other development efforts currently underway in HWVP could help provide resolution to this issue. If the projections of chromium concentrations for PFP sludge are accurate, the number of canisters needed for PFP sludge with TRUEX would increase from 100 to over 2,000. Without TRUEX, the projected number increases from 400 to over 8,000. Obviously a technique is needed to improve the ability of the melter to process higher concentrations of chromium. Development efforts are currently underway in HWVP to address the accumulation of noble metals in the melter. It is thought that the technique developed to accommodate noble metals, such as a bottom drain, could be used as the basis for increasing allowable concentrations of chromium in the glass.

Changing the order of the initial waste feed to HWVP from NCAW to PFP or NCRW would impact the HWVP feed specifications which are presently based on NCAW. This will have a direct impact on the WFQ effort. The WFQ strategy assumes that 6.5 yr is required from the completion of radioactive testing to the final acceptance of the Waste Qualification Report. The impact of the potential

processing changes to WFQ and subsequent potential impacts, if any to other HWVP project schedules need to be assessed as soon as possible.

- What is the effect of the processing options on grout?

The Final Environmental Impact Statement (DOE 1987) identified several key radionuclides in SST and DST wastes, including: ^{14}C, ^{90}Sr, ^{99}Tc, ^{106}Ru, ^{129}I, ^{137}Cs, ^{151}Sm, ^{239}Pu, ^{240}Pu, ^{241}Am. The distribution of the key radionuclides between grout and glass products from DST waste is briefly addressed in this section.

Table 7-1 shows the expected concentrations of key radionuclides in grout from treated DST wastes as a function of the sludge treatment process. They are compared with class A and C wastes as defined in 10 CFR 61 and the concentrations reported in the HDW-EIS on which the performance assessments were based. In sludge washing operations, ^{14}C, ^{99}Tc, and ^{129}I, because of their known aqueous phase solubility, are expected to remain in the grout product. They are also assumed to be sent to grout for the TRUEX process for conservatism, even though ^{99}Tc is expected to be stripped from the solvent and sent to glass. Conversely, ^{151}Sm, ^{239}Pu, ^{240}Pu, and ^{241}Am will all report to the glass product irrespective of the sludge treatment procedure. In the TRUEX process these latter nuclides are selectively extracted by the CMPO solvent and then co-stripped into a dilute HNO_3 solution which is combined with any undissolved sludge for vitrification.

Distribution of ^{137}Cs and ^{90}Sr between glass and grout products is of special concern and significance in processing of retrieved DST waste. Double-shell tank wastes contain significant concentrations of these key radionuclides. Because it is very water soluble, ^{137}Cs would generally be expected to distribute to

Table 7-1. Expected Concentrations in Grout (Ci/m³).

Radionuclides	NCAW	PFP sludge	NCRW	CC	Composite	HDW-EIS	10 CFR 61	
	Sludge wash/ TRUEX	Sludge wash/ TRUEX	Sludge wash/ TRUEX	Complexant/ destruction TRUEX	Sludge wash/ TRUEX		Class A	Class C
^{90}Sr	N/48[a]	N/28[b]	N/2.3	N/30[c]	N/33[d]	5 to 10	0.04	7,000
^{137}Cs	78/55	4.8/2.3	20/10	85/77	79/65	40 to 60	1	4,600
^{14}C	NP/NP	NP/NP	NP/NP	NP/NP	NP/NP	0.003 to 0.01	0.8	8
^{99}Tc	NP/NP	NP/NP	0.0097/0.0051	NP/NP	5.6 E – 04/4.7 E – 04	0.05 to 0.08	0.3	3
^{129}I	NP/NP	NP/NP	NP/NP	NP/NP	NP/NP	10^{-4}	0.008	0.08
Alpha (TRU) nCi/g	N/N	N/N	N/N	N/N	N/N	6 to 67	10	100

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[a]Assumes removal of ^{90}Sr using rare earth sulfate precipitation.
[b]1.4 with ^{90}Sr removal.
[c]1.5 with ^{90}Sr removal.
[d]10 with ^{90}Sr removal.
N = Negligible - assumes all radionuclides go to glass for lack of conclusive data to indicate otherwise.
NP = Not present or not analyzed.

the grout product in both the sludge washing and TRUEX process treatments. The exception is with NCAW which employes a radiocesium removal step with ion exchange resins. For this study, 95% of the radiocesium in NCAW is expected to be removed from the grout stream and directed to the vitrification feed tank.

Over 90% of the ^{90}Sr in DST waste is present as water-insoluble forms in the sludge fraction of the waste. Hence, glass made from water-washed sludge will still contain essentially all the ^{90}Sr initially present in the sludge, leaving negligible amounts in the grout product. But 75% of ^{90}Sr, solubilized when the sludge is dissolved in acid solutions, is not extracted by the TRUEX process solvent and remains in the aqueous raffinate which, after addition of NaOH, constitutes feed to the grout process.

Comprehensive performance assessments and other* studies must be performed to fully evaluate environmental and other impacts of near-surface disposal in grout form of all of or part of the inventory of ^{137}Cs, ^{90}Sr, uranium and various other key radionuclides in DST and SST wastes. The environmental impacts of near-surface disposal of hazardous chemicals in these wastes also need to be evaluated. Such performance assessments may show the necessity or desirability of removing selected components of the dissolved DST sludge prior to grouting and near-surface disposal.

The primary component to be considered for removal is ^{90}Sr to meet the grout concentrations assumed in the HDW-EIS and to satisfy the heat loading limits in grout. Incorporation of a 95% strontium

*For example, detailed analysis of the thermal stresses on grout properties and behavior as well as on all components of the grout disposal system from the ^{137}Cs and/or ^{90}Sr content of all DST wastes needs to be done. Also the effects of organics introduced from the wastes and the TRUEX process must be evaluated.

removal process for the TRUEX process raffinate would reduce concentrations to values consistent with the HDW-EIS. Table 7-1 exemplifies the need for strontium removal for NCAW, PFP and possibly CC wastes.

Candidate ^{90}Sr removal processes include scavenging by preformed antimonic acid ($Sb_2O_5 \times H_2O$), solvent extraction by bis(hexoxyethyl)-phosphoric acid, and rare earth precipitation in sulfate solutions (see Section 4.2). But, plant scale application of these (or other potential ^{90}Sr removal technology) processes will require extensive testing and development with both simulated and actual dissolved DST and SST sludges.

Before considering the need for strontium removal processes or other pretreatment enhancements, characterization data and knowledge of pretreatment efficiencies must be obtained. Characterization and process development testing must be accelerated to support the selection and design of pretreatment processes.

- What is the impact of the processing options on DST space availability and waste retrieval capabilities?

  Preliminary assessments indicate that two additional DSTs are required to store the waste as compared to the requirement in Riley 1988a for applying the TRUEX process to all DST waste, or for in-tank washing PFP waste or NCAW and application of the TRUEX process to the remaining DST waste. Preliminary evaluations also indicate that it will take approximately one year to retrieve waste from a DST.

- Can the NCAW sludge be successfully washed in a DST?

  The proposed washing of NCAW sludge in existing DSTs or in AR Vault requires a technical analysis to assure that there are no safety issues as a result of excessive temperatures in the settled

sludge. The current programs for waste retrieval and solids washing need to be reviewed and modified if necessary to support NCAW washing in a DST. The impact of washing NCAW sludge in a DST on waste volume projections and tank space availability in the 1990s needs to be determined.

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APPENDIX A

PROCESS FLOWSHEETS

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APPENDIX A
PROCESS FLOWSHEETS

This appendix provides simplified process flow diagrams of the pretreatment process options considered in this study (Figures A-1 through A-10). The preferred alternative shown in the Hanford Waste Management Plan (DOE-RL 1987) is noted in the figure caption. The pretreatment options shown do not include optional cesium and/or strontium removal steps for Plutonium Finishing Plant (PFP) waste, neutralized cladding removal waste (NCRW), and complexant concentrate (CC). These steps would be considered to reduce the fission product concentration in the grout product, if desirable or necessary.

This appendix also provides preliminary chemical process flowsheets for the baseline transuranic extraction (TRUEX) process for PFP waste, NCRW, CC, and SST waste (Figures A-11 through A-14). The NCAW sludge washing flowsheet is provided in Gibson, Landeen, 1987. The flowsheets provide the bases for grout volume and canister number projections for each waste type. The flowsheets also provide waste stream compositions and volumes which were used to approximate the pretreatment facility equipment requirements and throughout rates.

The glass canister projections (Tables A-1 through A-4) which are highlighted in the tables of this appendix, are based on a maximum of 25 wt% total waste oxides in the glass product. There are two special considerations, however: (1) In the case of NCRW, the individual waste oxide limit for zirconium governs the canister projections. The canister projection of 400 for NCRW is based on the Zr oxide limit of 15 wt%, not the 340 canisters projected by the 25 wt% total waste oxide limit and (2) Although the canister projections for PFP are 100 cans with TRUEX using the total waste oxide limit, it is over 2000 cans based on the 0.5 wt% limit for chromium oxide. Since PFP has not been fully characterized to confirm the chromium content and since development of techniques to substantially increase the waste oxide limit for chromium is likely, it was not considered reasonable to increase the canister projection beyond 100.

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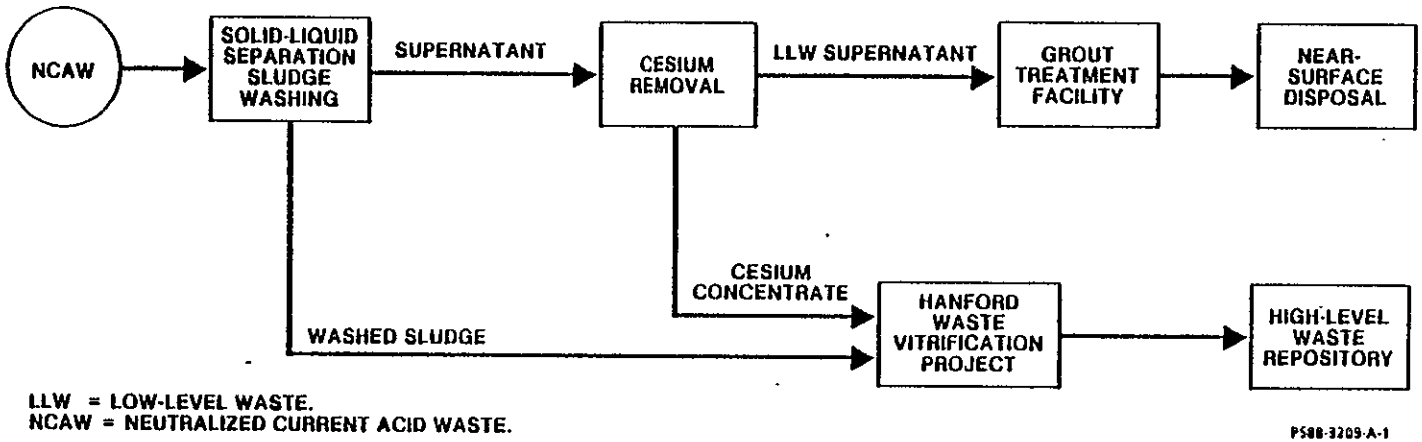


Figure A-1. Neutralized Current Acid Waste Pretreatment Process Options--Sludge Washing, Cesium Removal--Current Hanford Waste Management Plan Baseline.

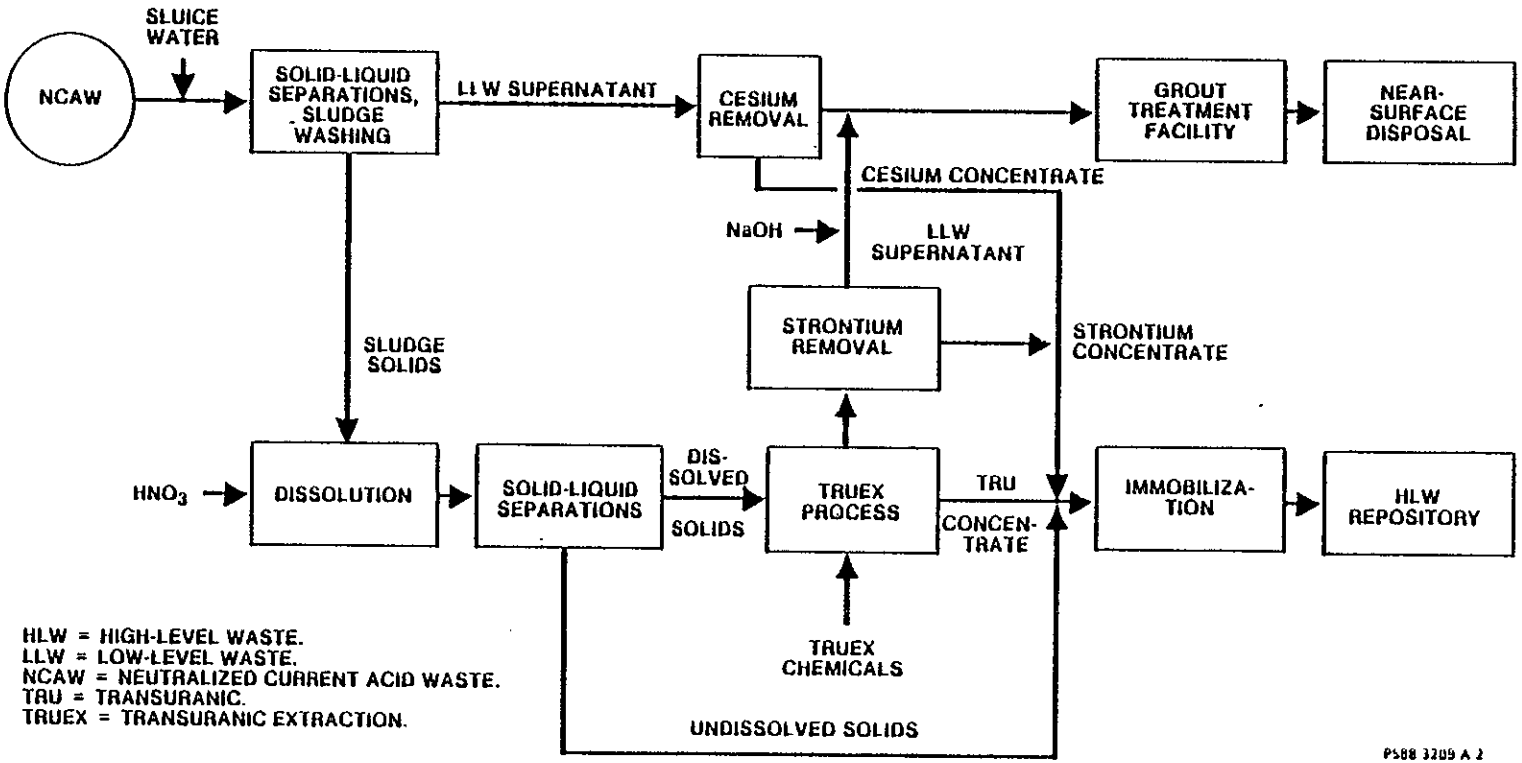


Figure A-2. Neutralized Current Acid Waste Pretreatment Process Options--Sludge Washing, Cesium Removal, Transuranic Extraction, Strontium Removal.

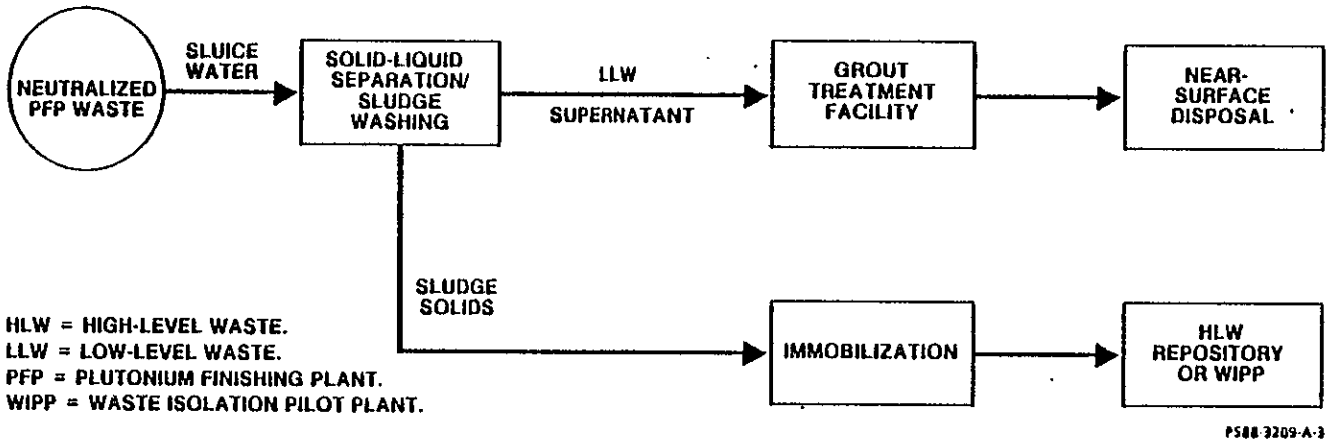


Figure A-3. Plutonium Finishing Plant Waste Pretreatment Options--Sludge Washing.

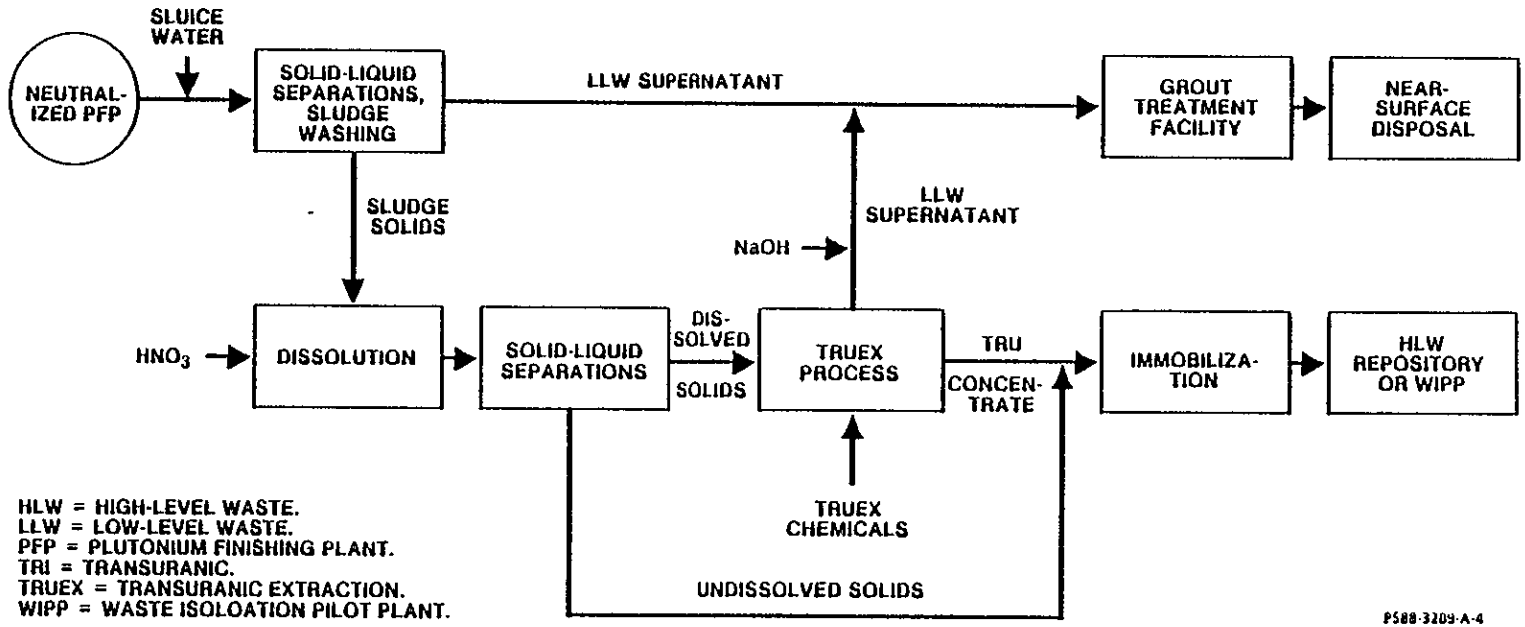


Figure A-4. Plutonium Finishing Plant Waste Pretreatment Options--Transuranic Extraction--Current Hanford Waste Management Plan Baseline.

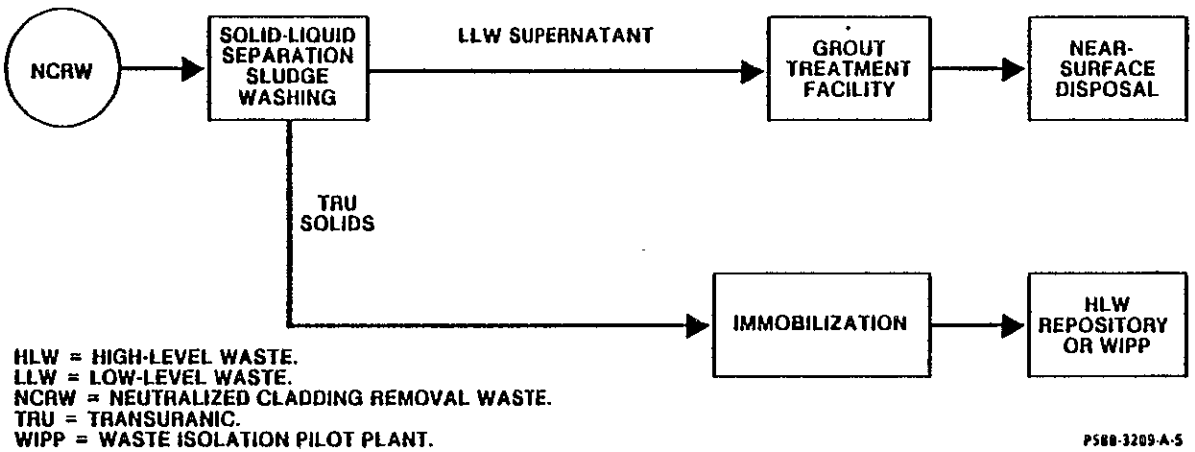
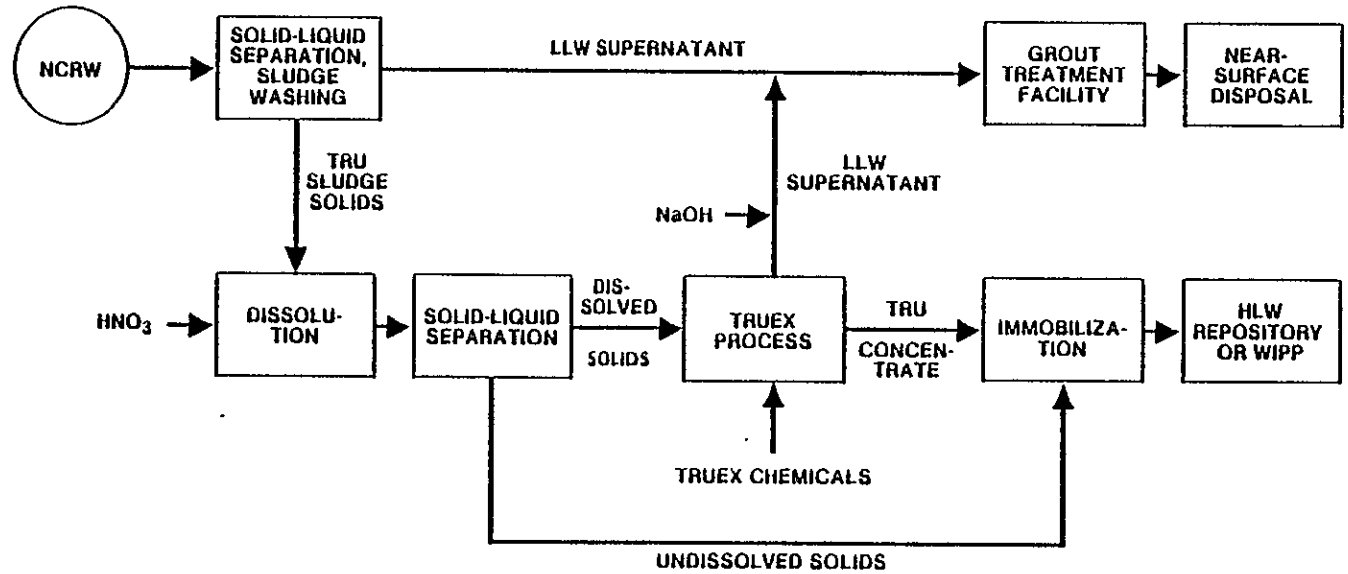


Figure A-5. Neutralized Cladding Removal Waste Pretreatment Process Options--Sludge Washing.



HLW = HIGH-LEVEL WASTE.
LLW = LOW-LEVEL WASTE.
NCRW = NEUTRALIZED CLADDING REMOVAL WASTE.
TRU = TRANSURANIC.
TRUEX = TRANSURANIC EXTRACTION.
WIPP = WASTE ISOLATION PILOT PLANT.

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Figure A-6. Neutralized Cladding Removal Waste Pretreatment Process Option--Transuranic Extraction--Current Hanford Waste Management Plan Baseline.

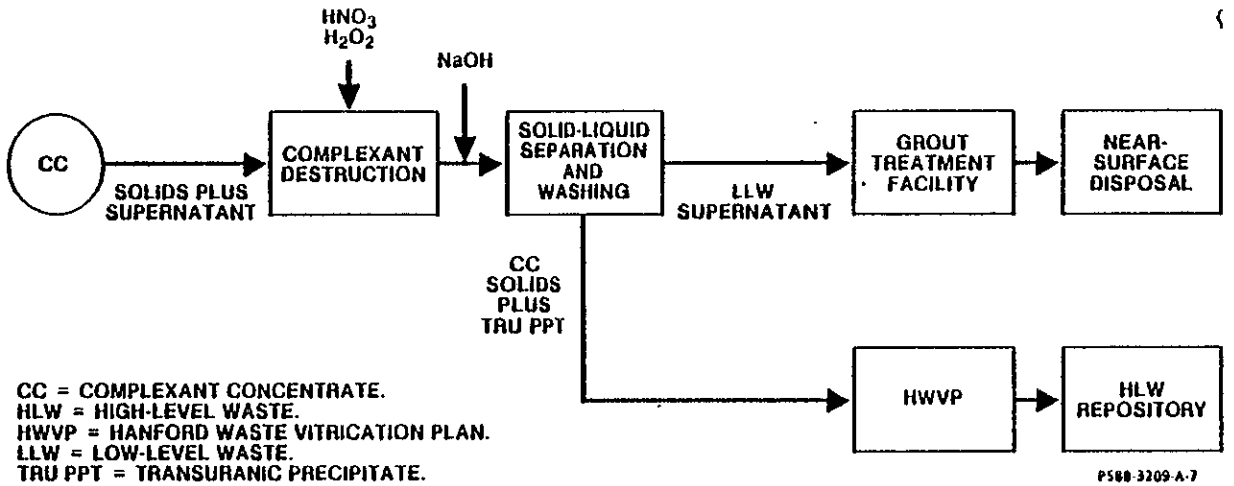


Figure A-7. Complexant Concentrate Pretreatment Process Options--Complexant Destruction.

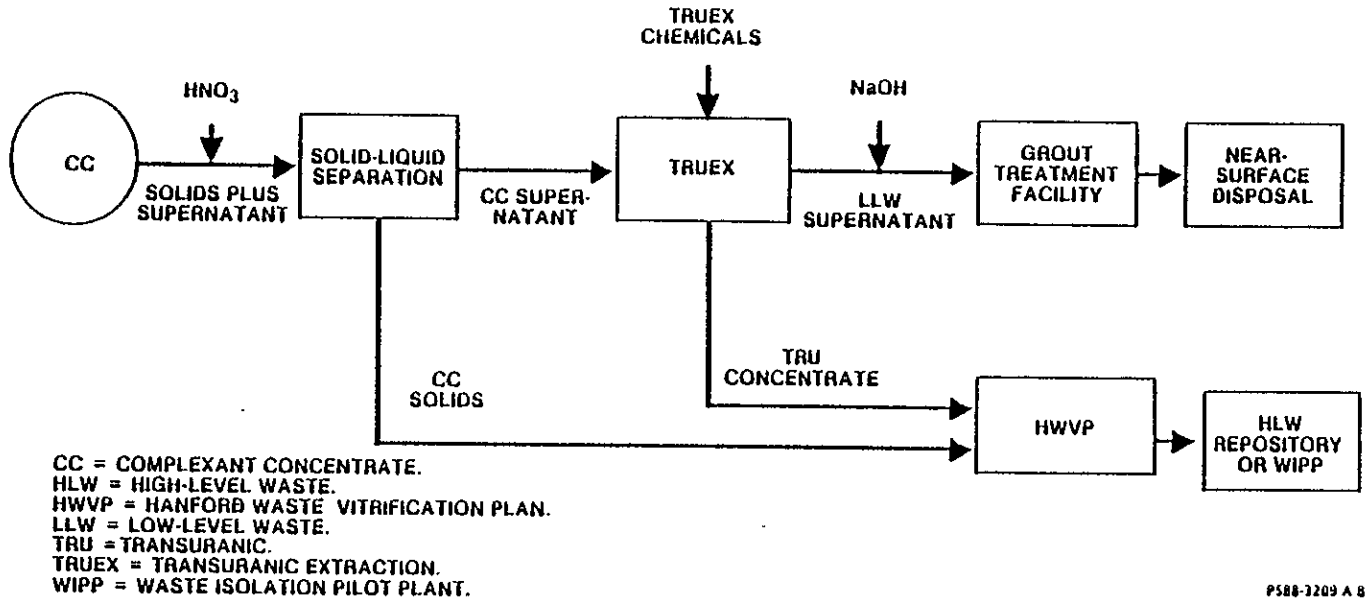


Figure A-8. Complexant Concentrate Pretreatment Process Options--Transuranic Extraction--Current Hanford Waste Management Plan Baseline.

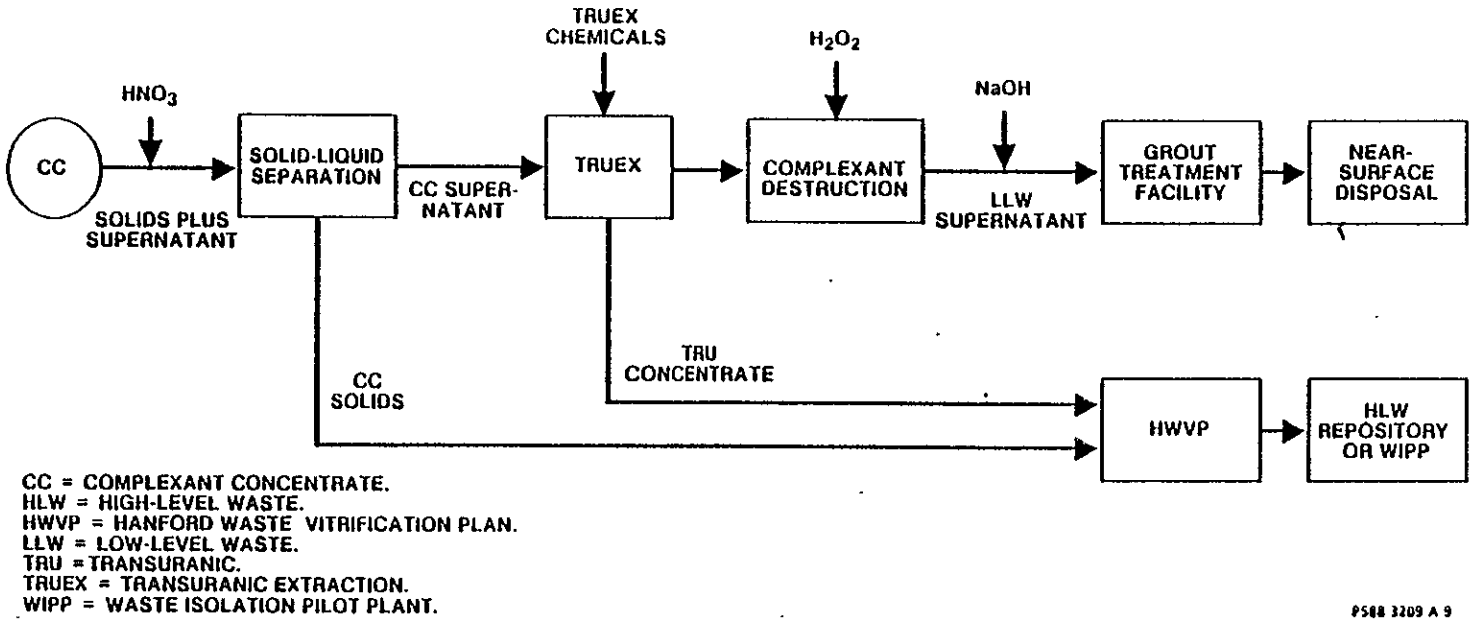


Figure A-9. Complexant Concentrate Pretreatment Process Options--Transuranic Extraction, Complexant Destruction.

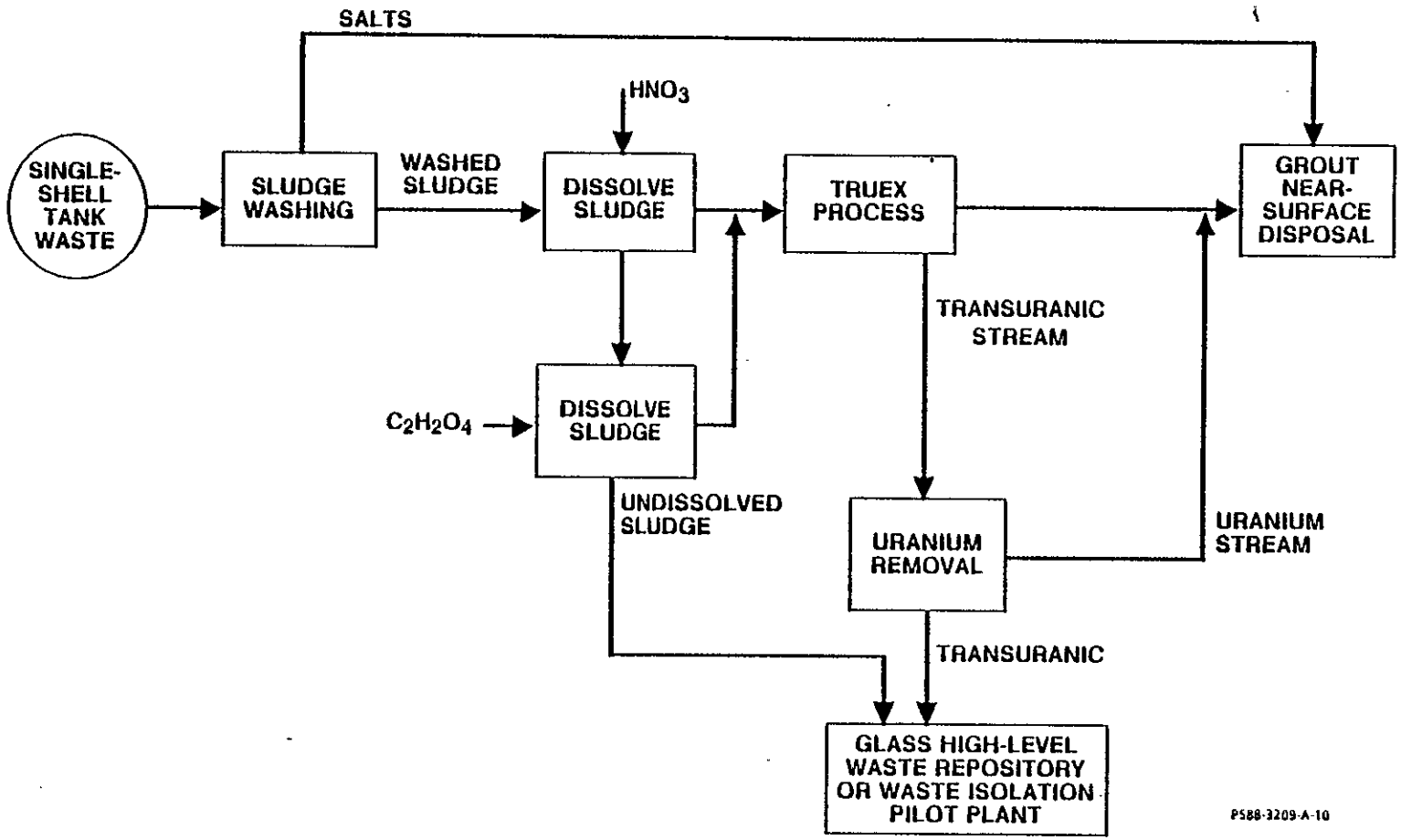
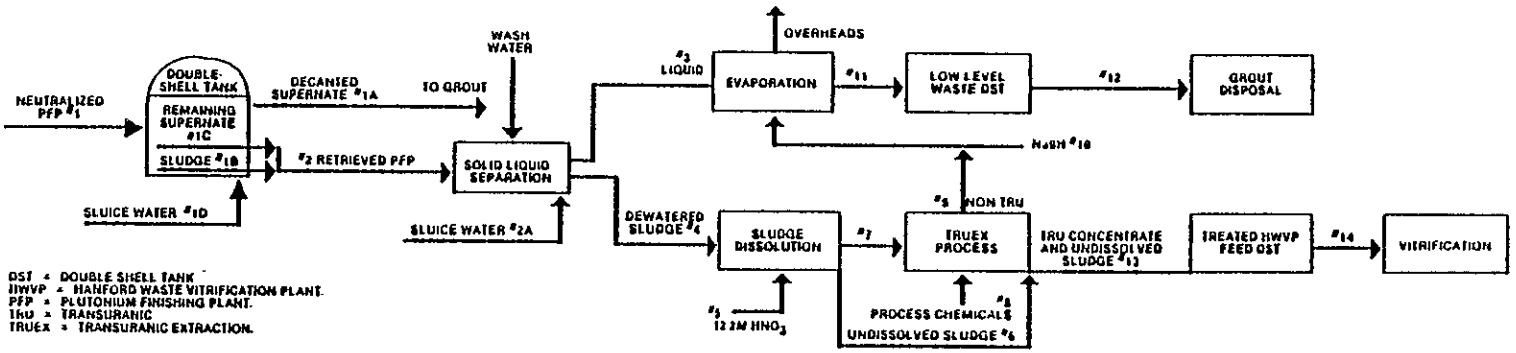


Figure A-10. Flow Diagram of Acid Dissolution - Transuranic Extraction Process with Uranium Removal for Pretreatment of Single-Shell Tank Wastes.



DST = DOUBLE SHELL TANK
HWVP = HANFORD WASTE VITRIFICATION PLANT
PFP = PLUTONIUM FINISHING PLANT
TRU = TRANSURANIC
TRUEX = TRANSURANIC EXTRACTION

Element (gmol/L)	Stream No.1	Stream No. 1A	Stream No 1B	Stream No 1C	Stream No. 1D	Stream No 2	Stream No 2A	Stream No 3	Stream No. 4	Stream No 5	Stream No. 6	Stream No. 7	Stream No 8	Stream No 9	Stream No 10	Stream No 11	Stream No. 12	Stream No. 13	Stream No. 14
H^+	--	--	--	--	--	--	--	--	--	12 200	0 000	1 008	0.224	0 546	--	--	--	0 048	0 000
OH^-	1.185	1 111	1 028	1 185	--	0 403	--	0.133	0 226	--	0 223	0 000	--	0 000	10 040	1 256	1.256	0.118	0 071
Na	1.900	1 916	1.768	1 900		0 693	--	0 226	0 389	--	0 389	0 270	--	0 243	10 000	1 000	1 000	0 203	0 203
$AlO_2^- \rightarrow Al^{+3}$	0 169	0 179	0 323	0.189		0 114	--	0 022	0 154	--	0.154	0 134	0.025	0.125	-	0 293	0 293	0.109	0 169
$SO_4^=$	0 106	0.108	0.093	0.108	-	0 016	--	0 012	0 020	-	0 020	0 016	--	0 013	--	0.101	0 101	0 011	0 011
F^-	0 059	0.100	0 092	0 059	--	0 016	--	0 012	0.020	--	0 020	0 014	0 032	0 012	--	0.100	0.100	0 034	0 034
$Ca(OH)2 \rightarrow (NO_3)2$	0 000	0 000	0 169	0 000	--	0 010	--	0 000	0.111	--	0.111	0 072	--	0 078	--	0 074	0 074	0 058	0 058
$Mg(OH)2 \rightarrow (NO_3)2$	0 010	0 000	0.141	0 010	--	0 044	--	0 000	0.143	--	0.143	0 100	--	0 090	--	0 096	0 096	0 075	0 075
$Fe(OH)3 \rightarrow (NO_3)3$	0 012	0 000	0.173	0 012	--	0 054	--	0 000	0.176	--	0 176	0 122	--	0 078	--	0 084	0 084	0.178	0 170
$Mn(OH)2 \rightarrow (NO_3)2$	0 003	0 000	0 049	0 003	--	0 015	--	0 000	0 058	--	0 058	0 035	--	0 031	--	0 033	0 033	0 026	0 026
$Cr(OH)3 \rightarrow (NO_3)3$	0 041	0 000	0.598	0 041	--	0 184	--	0 000	0.606	--	0 600	0 417	--	0 375	--	0 401	0 401	0 313	0 313
Cr (soluble)	0 023	0 026	0 000	0 023	--	0 002	--	0 000	0 006	--	0 006	0 004	-	0 004	--	0 004	0 004	0 003	0 003
NO_3^- and NO_2^-	0 684	0 686	0 637	0 684	--	0.250	--	0 003	0.148	12 200	0 148	0 038	0.192	3.484	--	4.331	4 331	0 121	0 121
CMPO and TBP	--	-	--	--	--	--	--		-	--	--	-	0 002	0 000	-	0 000	0 000	0 002	0 002
$H_2C_2O_4$	-	--	--	--	--	--	--	--	--	--	--	--	0.558	0.156	--	0.157	0 157	0 016	0 016
U (g/L)	4.80E 04	0 000	0 007	4.80E 04	--	0 002	--	0 000	0 007	-	0 007	0 005	--	0 000	--	-	0 000	0 015	0 015
Pu (g/L)	4.50E 03	0 000	0 070	4.50E 03	--	0 022		0 000	0 072	--	0 072	0 050	-	0 000		0 006	0 006	0.150	0 150
Am (g/L)	4.20E 04	0 000	0 006	4.20E 04	-	0 002	--	0 000	0 006	--	0 006	0 004		0 000	-	0 000	0 000	0 013	0 013
$^{90}Sr,Y$ (Ci/L)	0 004	0 000	0 055	0 004	--	0 017	--	0 000	0 056	-	0 056	0 039	--	0 035	--	0 037	0 037	0 029	0 029
$^{137}Cs,Ba$ (Ci/L)	0 003	0 003	0 002	0 003	--	0 001	--	0 000	0 001	--	0 001	0 000	-	0 000	--	0 003	0 003	2 69E 04	2 69E 04
Stream volume (m^3)	21613	19577	1463	378	3926	4767	2926	11081	1463	444	366	1581	518	1756	265	1648	1648	700	700

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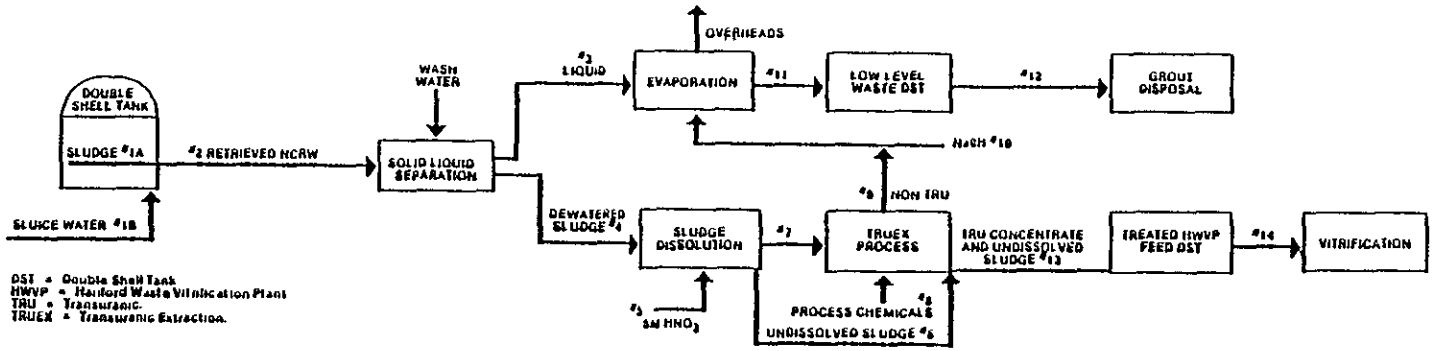
Figure A-11. Overall Process Scheme for Removing Transuranic Elements from Plutonium Finishing Plant Sludge.



Element (g-mol L)	Stream No. 1A	Stream No 1B	Stream No. 2	Stream No. 3	Stream No 4	Stream No 5	Stream No 6	Stream No 7	Stream No 8	Stream No 9	Stream No 10	Stream No 11	Stream No 12	Stream No 13	Stream No 14
H^+	--	--	--	--	--	5.000	0.000	1.000	0.148	0.324	--	--	--	0.064	0.008
OH^-	0.869	--	0.435	0.000	0.869	--	0.049	0.000	--	0.000	19.000	0.867	0.867	0.017	0.018
Na	6.285	--	3.255	0.638	4.679	--	0.703	2.744	--	2.478	19.648	5.000	5.000	0.249	0.385
K^+	0.249	--	0.125	0.000	0.249	--	0.026	0.113	--	0.101	-	0.097	0.097	0.009	0.009
$AlO_2^- \rightarrow Al^{+3}$	0.134	--	0.067	0.000	0.134	--	0.018	0.018	--	0.052		0.050	0.050	0.013	0.013
S^-	5.256	--	2.648	0.638	4.665	--	0.636	2.095	0.032	1.865	--	2.048	2.048	0.257	0.257
$Ca(OH)_2 \rightarrow (NO_3)_2$	0.028	--	0.014	0.000	0.028	--	0.026	0.010	--	0.000	--	0.000	0.000	0.010	0.010
$Fe(OH)_3 \rightarrow (NO_3)_3$	0.068	--	0.030	0.000	0.068	--	0.058	0.021	--	0.014	-	0.014	0.014	0.035	0.035
$Mn(OH)_2 \rightarrow (NO_3)_2$	0.030	--	0.015	0.000	0.030	--	0.026	0.011	--	0.010	--	0.009	0.009	0.011	0.011
$Cr(OH)_3 \rightarrow (NO_3)_3$	0.027	--	0.013	0.000	0.027	-	0.027	0.008	--	0.006	--	0.008	0.008	0.009	0.009
$La(OH)_3 \rightarrow (NO_3)_3$	0.003	--	0.002	0.000	0.003	-	0.003	0.001	--	0.001	--	0.001	0.001	0.001	0.001
$Zr(OH)_4 \rightarrow (NO_3)_4$	1.650	--	0.525	0.000	1.050	-	1.050	0.366	--	0.329		0.314	0.314	0.372	0.371
$Sn(OH)_2 \rightarrow (NO_3)_2$	0.006	--	0.004	0.000	0.008	--	0.006	0.003	--	0.003	-	0.002	0.002	0.003	0.003
NO_3^- and NO_2^-	0.793	--	0.397	0.000	0.793	5.000	0.044	1.670	0.116	3.263	-	3.130	3.130	0.048	0.048
CMPO and TBP	--	--	0.000	0.000	0.000		0.000	0.000	0.002	0.000	--	0.000	0.000	0.002	0.002
$H_2C_2O_4$	--	--	0.000	0.000	0.000	-	0.000	0.000	0.558	0.156	-	0.148	0.148	0.021	0.021
^{238}U (Ci L)	2.70E-06	--	0.000	0.000	0.000	--	0.000	0.000	--	0.000	-	0.000	0.000	3.83E 04	3.83E 04
^{238} & ^{240}Pu (Ci L)	8.84E 04		0.000	0.000	0.001		0.001	0.000	--	0.000	-	0.000	0.000	1.25E 03	1.25E 03
^{241}Pu (Ci L)	8.11E 03	--	0.004	0.000	0.008	-	0.008	0.003	--	0.000	--	0.000	0.000	1.15E 02	1.15E 02
^{241}Am (Ci L)	5.47E 04		0.000	0.000	0.001		0.001	0.000	--	0.000		0.000	0.000	7.75E 04	7.73E 04
^{90}SrY (Ci L)	0.018	--	0.005	0.000	0.018		0.010	3.44E 03	--	3.10E 03		2.95E 03	2.95E 03	3.50E 03	3.50E 03
$^{137}CsBa$ (Ci L)	0.014	--	0.013	0.000	0.014	-	0.002	1.55E 02	--	1.40E 02		1.33E 02	1.33E 02	6.73E 04	6.71E 04
Stream volume (m^3)	1009	1009	6018	1009	3009	4.21	151	6473	2083	7192	951	7544	7544	2123	2129

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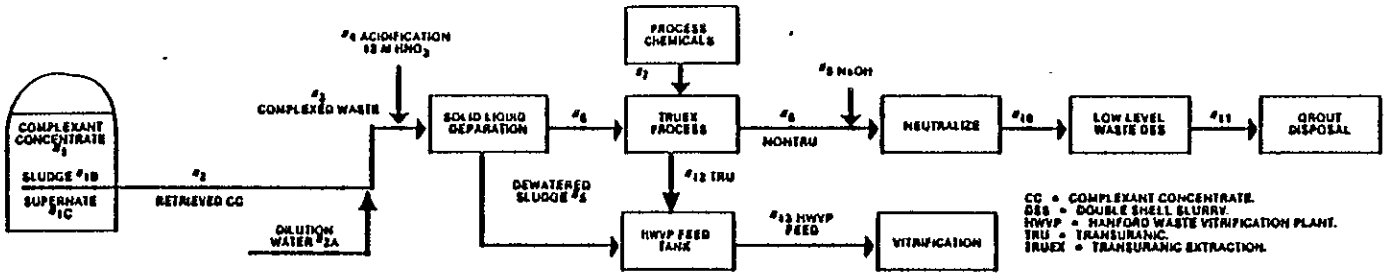
Figure A-12. Overall Process Scheme for Treating Neutralized Cladding Removal Waste with Transuranic Extraction Process.



Element (g-mol/L)	Stream No. 1A	Stream No. 1B	Stream No. 1C	Stream No. 2	Stream No. 2A	Stream No. 3	Stream No. 4	Stream No. 5	Stream No. 6	Stream No. 7	Stream No. 8	Stream No. 9	Stream No. 10	Stream No. 11	Stream No. 12	Stream No. 13
H^+	–	–	–	–	–	–	13.200	–	1.000	0.166	0.834	–	–	–	0.196	0.000
OH^-	0.645	0.113	0.416	0.645	–	0.378	–	0.113	0.000	–	0.000	10.000	0.545	0.545	0.000	0.424
Na	10.151	3.444	10.300	10.151	–	5.150	–	3.444	5.594	–	5.300	10.000	5.000	5.000	0.000	6.196
Al	0.733	0.944	0.796	0.733	–	0.838	–	0.944	0.485	–	0.365	–	0.174	0.174	0.000	0.054
Fe	0.045	1.343	0.016	0.045	–	0.015	–	1.343	0.009	–	0.007	–	0.004	0.004	0.007	0.003
Mg	0.014	0.549	0.001	0.014	–	0.001	–	0.549	0.000	–	0.000	–	0.000	0.000	0.000	0.035
Cr	0.018	0.241	0.013	0.018	–	0.011	–	0.241	0.047	–	0.007	–	0.004	0.004	0.000	0.014
Mn	0.019	0.341	0.012	0.019	–	0.011	–	0.341	0.047	–	0.006	–	0.003	0.003	0.000	0.019
Ca	0.016	0.116	0.013	0.016	–	0.013	–	0.116	0.000	–	0.007	–	0.004	0.004	0.000	0.000
Si	0.118	4.933	0.003	0.118	–	0.003	–	4.933	0.003	–	0.001	–	0.001	0.001	0.000	0.256
La	0.003	0.047	0.001	0.003	–	0.001	–	0.047	0.000	–	0.000	–	0.000	0.000	0.000	0.005
SO_4^{2-}	0.055	0.000	0.057	0.055	–	0.005	–	0.065	0.055	–	0.049	–	0.025	0.025	0.000	0.003
F^-	0.128	0.000	0.126	0.133	–	0.112	–	0.000	0.073	0.033	0.074	–	0.030	0.030	0.050	0.047
NO_3^- and NO_2^-	4.559	0.000	4.648	4.559	–	4.164	13.200	0.000	7.150	0.116	0.476	–	3.443	3.443	0.050	0.047
PO_4^{3-}	0.045	0.000	0.046	0.045	–	0.041	–	0.000	0.026	–	0.026	–	0.013	0.013	0.000	0.000
CO_3^{2-}	0.521	0.135	0.318	0.521	–	0.024	–	0.135	0.000	–	0.000	–	0.000	0.000	0.000	0.000
Cl^-	0.119	0.000	0.122	0.119	–	0.106	–	0.000	0.078	–	0.043	–	0.022	0.022	0.000	0.000
CMPO and TBP	0.000	0.000	0.000	0.000	–	0.000	–	0.000	0.000	0.043	0.000	–	0.000	0.000	0.004	0.043
$H_2C_2O_4$	0.000	0.000	0.000	0.000	–	0.000	–	0.000	0.000	0.556	0.000	–	0.000	0.000	0.038	0.042
TOC as carbon	0.321	0.268	0.322	0.321	–	0.165	–	0.268	0.184	–	0.156	–	0.000	0.000	0.000	0.015
U (g/L)	0.279	14.583	6.31E-02	0.279	–	0.035	–	14.583	0.035	–	0.000	–	0.000	0.000	0.171	0.549
$239,240$ & 241_{Pu} (Ci/L)	0.000	0.004	4.15E-04	0.000	–	0.000	–	0.004	0.004	–	0.000	–	0.000	0.000	0.001	0.001
154 & 155_{Eu} (Ci/L)	0.005	0.000	5.03E-03	0.005	–	0.004	–	0.000	0.003	–	0.000	–	0.000	0.000	0.014	0.013
241_{Am} (Ci/L)	0.001	0.018	4.31E-04	0.001	–	0.000	–	0.018	0.000	–	0.000	–	0.000	0.000	0.001	0.003
89 & 90_{Sr} (Ci/L)	0.135	0.000	0.139	0.135	–	0.124	–	0.000	0.069	–	0.032	–	0.016	0.016	0.000	0.000
137_{Cs} (Ci/L)	0.358	0.000	0.366	0.358	–	0.331	–	0.000	0.215	–	0.183	–	0.100	0.100	0.000 + 00	0.000
Stream volume (m^3)	16.161	353	15.789	16.141	1.614	17.755	18.159	353	25.573	0.099	30.633	0.665	57.600	57.600	5.039	6.196

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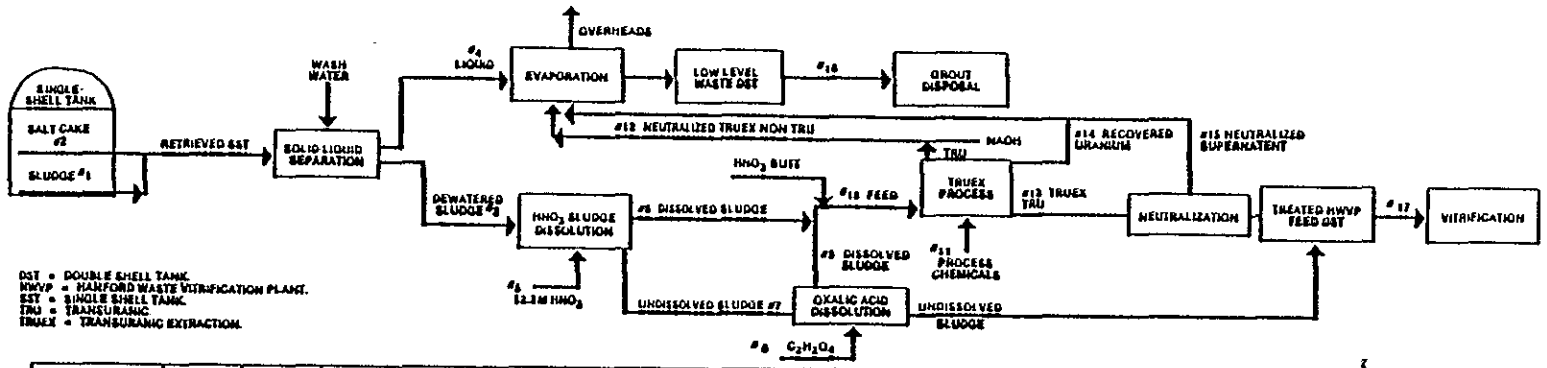
Figure A-13. Overall Process Scheme for Treating Complexant Concentrate with Transuranic Extraction Process.



Component (g-mole)	Stream No. 1	Stream No. 2	Stream No. 3	Stream No. 4	Stream No. 5	Stream No. 6	Stream No. 7	Stream No. 8	Stream No. 9	Stream No. 10	Stream No. 11	Stream No. 12	Stream No. 13	Stream No. 14	Stream No. 15	Stream No. 16	Stream No. 17
HNO_3	0.000	0.000	0.000	0.000	12.300	0.000	0.000	--	0.000	0.000	0.743	0.000	4.06 E-02	0.000	0.00 E+00	0.000	0.00 E+00
$C_2H_2O_4$	0.000	0.000	0.000	0.000	--	0.000	0.000	1.041	0.744	0.300	--	0.000	0.00 E+00	(0.000)	0.00 E+00	0.000	0.00 E+00
$NaNO_3$	5.144	14.823	0.232	4.569	--	0.168	0.232	--	0.643	0.129	--	1.745	0.00 E+00	(0.000)	4.62 E-02	3.386	1.96 E-01
$NaNO_2$	0.550	0.659	0.016	0.335	--	0.012	0.016	--	0.004	0.000	--	0.045	0.00 E+00	(0.000)	0.00 E+00	0.182	1.50 E-02
Na_2CO_3	0.351	0.662	0.005	0.005	--	0.003	0.006	--	0.001	0.000	0.018	0.000	0.00 E+00	0.123	0.00 E+00	0.049	3.02 E-03
NaOH	2.285	0.742	0.032	0.568	--	0.030	0.032	--	0.009	0.000	--	1.000	0.00 E+00	0.000	0.00 E+00	0.710	0.00 E+00
$NaAlO_2$	0.253	0.449	0.002	0.140	--	0.005	0.002	--	0.017	0.040	--	0.022	0.00 E+00	0.000	0.00 E+00	0.000	6.92 E-02
Na_2SO_4	0.114	0.130	0.006	0.052	--	0.004	0.006	--	0.001	0.003	--	0.001	0.00 E+00	(0.000)	0.00 E+00	0.026	4.68 E-03
Na_3PO_4	1.663	0.152	0.010	0.351	--	0.013	0.010	--	0.004	0.000	--	0.005	0.00 E+00	0.000	0.00 E+00	0.282	1.56 E-02
Concrete	0.000	0.000	0.000	0.000	--	0.000	0.000	--	0.000	0.000	--	0.000	0.00 E+00	0.000	0.00 E+00	0.000	3.43 E-01
$Al(OH)_3$	0.645	0.000	0.645	0.000	--	0.044	0.645	--	0.136	0.333	--	0.172	0.00 E+00	(0.000)	0.00 E+00	0.063	5.44 E-01
$Ca(OH)_2$	0.037	0.000	0.037	0.000	--	0.025	0.037	--	0.008	0.018	--	0.010	0.00 E+00	(0.000)	0.00 E+00	0.004	3.09 E-02
$Cr(OH)_3$	0.046	0.000	0.046	0.000	--	0.020	0.046	--	0.000	0.010	--	0.011	0.00 E+00	0.000	0.00 E+00	0.004	3.41 E-02
$Fe(OH)_3$	0.243	0.000	0.243	0.000	--	0.168	0.243	--	0.052	0.010	--	0.066	0.00 E+00	(0.000)	0.00 E+00	0.024	3.81 E-01
$BiPO_4$	0.027	0.000	0.027	0.000	--	0.010	0.027	--	0.006	0.012	--	0.007	0.00 E+00	(0.000)	0.00 E+00	0.003	2.31 E-02
$CaCO_3$	0.070	0.000	0.070	0.000	--	0.048	0.070	--	0.015	0.034	--	0.019	0.00 E+00	(0.000)	0.00 E+00	0.007	5.90 E-03
Cl-	0.005	0.000	0.000	0.005	--	0.000	0.000	--	0.000	0.000	--	0.000	0.00 E+00	0.000	0.00 E+00	0.003	0.00 E+00
F-	0.031	0.003	0.028	0.178	--	0.010	0.028	--	0.005	0.013	--	0.007	0.00 E+00	(0.000)	4.82 E-02	0.251	2.34 E-03
MnO_2	0.048	0.000	0.048	0.000	--	0.033	0.048	--	0.010	0.023	--	0.013	0.00 E+00	(0.000)	0.00 E+00	0.005	4.04 E-02
$Ni_2Fe(CN)_6$	0.033	0.000	0.033	0.000	--	0.023	0.033	--	0.000	0.016	--	0.000	0.00 E+00	(0.000)	0.00 E+00	0.003	2.86 E-02
$ZrO_2 \cdot 2H_2O$	0.059	0.000	0.059	0.000	--	0.041	0.059	--	0.012	0.028	--	0.015	0.00 E+00	(0.000)	0.00 E+00	0.006	4.92 E-02
U	0.131	0.000	0.102	0.000	--	0.070	0.102	--	0.022	0.049	--	0.000	4.94 E-04	0.121	0.00 E+00	0.000	1.82 E-01
^{241}Am	1.84 E-06	--	1.84 E-06	--	--	--	1.84 E-06	--	--	5.81 E-07	--	--	2.51 E-07	--	--	--	8.77 E-06
^{237}Np	6.65 E-06	--	6.65 E-06	--	--	--	6.65 E-06	--	--	2.92 E-06	--	--	1.46 E-06	--	--	--	5.11 E-05
^{239} & ^{240}Pu	4.65 E-05	--	4.65 E-05	--	--	--	4.65 E-05	--	--	2.34 E-05	--	--	1.17 E-05	--	--	--	4.09 E-04
Volume(m^3)	28.523	28.000	28.523	161.000	13.783	33.334	7.456	17.066	21.764	37.451	158.742	162.636	114.183	22.628	510.536	262.528	3.636

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Figure A-14. Overall Process Scheme for Removing Transuranic Elements from Single-Shell Tank Sludge (75 Tanks).

Table A-1. Canister Projections for Plutonium Finishing Plant with Transuranic Extraction.

Element	Feed gmol/L	Total kg-mol	Fraction to glass	Kg-mol to glass	Mol wt oxide	Oxides kg	Oxides wt fraction	Glass limit wt fraction	Glass kg	Number of canisters
Na	1.900	40,693	0.004	142	31.00	4,415	0.105	0.055	8.03E + 04	49
Al	0.189	4,048	0.019	76	50.95	3,892	0.093	0.065	5.99E + 04	36
$SO_4^=$	0.100	2,133	0.004	7	80.00	597	0.014	0.005	1.19E + 05	73
F	0.099	2,120	0.011	24	19.00	458	0.011	0.017	2.69E + 04	16
Ca	0.008	163	0.250	41	56.00	2,279	0.055	0.050	4.56E + 04	28
Mg	0.010	210	0.250	52	40.30	2,115	0.050	0.050	4.23E + 04	26
Fe	0.012	257	0.464	119	79.85	9,519	0.227	0.150	6.35E + 04	39
Mn	0.003	73	0.250	18	70.90	1,291	0.031	0.050	2.58E + 04	16
Cr	0.041	878	0.250	220	76.00	16,684	0.398	0.005	3.34E + 06	2,000
Total	–	–	–	–	–	4.13E + 04	1.000	0.250	1.65E + 05	100

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Table A-2. Canister Projections for Neutralized Cladding Removal Waste with Transuranic Extraction.

Element	Feed gmol/L	Total kg-mol	Fraction to glass	Kg-mol to glass	Mol wt oxide	Oxides kg	Oxides wt fraction	Glass limit wt fraction	Glass kg	Number of canisters
Na	6.709	20,187	0.026	528	31.00	16,382	0.118	0.055	3.66E + 05	220
K	0.249	749	0.026	20	47.00	922	0.007	0.055	1.68E + 04	10
Al	0.134	403	0.070	28	50.95	1,438	0.010	0.065	2.21E + 04	13
F	5.296	15,935	0.034	546	19.00	10,381	0.075	0.017	1.73E + 06	370
Ca	0.028	83	0.250	21	56.00	1,167	0.008	0.050	2.33E + 04	14
Fe	0.060	180	0.421	76	79.85	6,038	0.044	0.150	4.03E + 04	24
Mn	0.030	91	0.250	23	70.90	1,621	0.011	0.050	3.24E + 04	20
Cr	0.027	81	0.250	20	76.00	1,532	0.011	0.005	3.06E + 05	190
La	0.003	9	0.250	2	163.00	368	0.003	0.050	7.36E + 03	4.5
Zr	1.050	3,159	0.250	790	123.00	97,149	0.702	0.150	6.48E + 05	400
Sn	0.008	25	0.250	6	135.00	833	0.006	0.050	1.67E + 04	10
Total	–	–	–	–	–	1.42E + 05	1.000	0.250	5.66E + 05	340

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Table A-3. Canister Projections for Complexant Concentrate with Transuranic Extraction.

Element	Feed gmol/L	Total kg-mol	Fraction to glass	Kg-mol to glass	Mol wt oxide	Oxides kg	Oxides wt fraction	Glass limit wt fraction	Glass kg	Number of canisters
Na	10.151	163,838	0.007	1,211	31.00	37,534	0.157	0.055	6.82E + 05	420
Al	0.713	11,510	0.029	332	50.95	16,900	0.071	0.065	2.60E + 05	160
Fe	0.045	713	0.702	513	79.85	40,987	0.172	0.150	2.73E + 05	170
Mg	0.014	218	0.948	207	40.30	8,345	0.035	0.050	1.67E + 05	100
Cr	0.018	287	0.295	85	76.00	6,429	0.027	0.005	1.29E + 06	780
Mn	0.019	311	0.386	120	70.90	8,501	0.035	0.050	1.70E + 05	100
Ca	0.016	255	0.188	48	56.00	2,680	0.011	0.050	5.36E + 04	33
Si	0.110	1,780	0.974	1,734	60.100	104,232	0.437	0.500	2.08E + 05	130
La	0.003	42	0.723	31	162.900	4,973	0.021	0.050	9.95E + 04	60
$SO_{4=}$	0.095	1,535	0.014	21	80.00	1,719	0.007	0.005	3.44E + 05	210
F^-	0.123	1989	0.146	291	19	5,527	0.023	0.017	3.25E + 05	200
Total	–	–	–	–	–	2.39E + 05	1.00E + 00	0.250	9.70E + 05	580

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Table A-4. Canister Projections for 75 Single-Shell Tanks with Transuranic Extraction.

Waste oxides component	Waste oxides (t)	Waste oxides (%)	Glass oxides (%)	Glass limit (%)	Number of canisters
Na_2O	456	22.0	5.5		
Al_2O_3	663	32.0	8.0		
SO_3	1	0.1	0.0		
P_2O_5	10	0.5	0.1		
SiO_2	647	31.2	7.8		
CeO_2	19	0.9	0.2		
Cr_2O_3	9	0.5	0.1		
Fe_2O_3	68	3.3	0.8		
SrO	3	0.1	0.0		
Bi_2O_5	21	1.0	0.3		
CaO	12	0.6	0.1		
MnO_2	13	0.6	0.2		
Ni_2O_3	17	0.8	0.2		
ZrO_2	22	1.1	0.3		
UO_3	106	5.1	1.3		
F^-	2	0.1	0.0		
Cl^-	0	0.0	0.0		
Total	2,071	100.0	25.0	25.000	5,100

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APPENDIX B

MAJOR ASSUMPTIONS AND COST BASES

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APPENDIX B

MAJOR ASSUMPTIONS AND COST BASES

The bases for estimating the disposal mission costs for the pretreatment options are provided in this appendix (Tables B-1 through B-3). Included are Hanford Site operational assumptions, Hanford Waste Vitrification Plant (HWVP) and Grout Treatment Facility (GTF) assumptions, and assumed capital and expense costs for the facility options. Costs judged to be minor and costs that are common to all of the alternatives are not included.

Also included in this appendix are total costs in Fiscal Year (FY) 1988 dollars for each process/facility option evaluated in Section 4.0 and Section 5.0 of this report (Tables B-4 through B-10). The cost elements (capital and operational) for each option are shown, as well as the pretreatment and vitrification start and completion dates. Expense costs are also provided on a year-by-year basis for the current baseline and preferred pretreatment alternative (Tables B-4 through B-9). Case designations for the options are defined in Appendix D.

HANFORD SITE OPERATIONAL ASSUMPTIONS

- N Reactor operations

- N Reactor does not resume operations

- Irradiated fuel in the inventory is processed in PUREX through 1992 (Ludowise 1988) (see Table B-1)

- The Process Facility Modification (PFM) (shear-leach) facility will not be constructed. Fast Flux Test Facility (FFTF) and pressurized water reactor (PWR) Core II fuels are to be processed at Hanford using existing or similar (to PFM) processing technology. One thousand three hundred and seventy-seven metric tons of uranium (MTU) of FFTF fuel and 51 MTU of PWR fuel are processed in FY 1992 and FY 1993, respectively (see Table B-1)

• Plutonium Finishing Plant (PFP) operations

- Plutonium Finishing Plant operating through FY 1997 using sequential operations of the Plutonium Reclamation Facility (PRF) and Remote Mechanical "C" Line

- The transuranic extraction (TRUEX) process will be available for treating PRF raffinate in FY 1993

• The HWVP operations--The HWVP will begin operations in fourth quarter FY 1999

Table B-1. The PUREX Facility Operating Schedule.

Fiscal year	Metric tons of uranium
1984	1,047
1985	1,057
1986	1,077
1987	125
1988	400
1989	537
1990	600
1991	600
1992	640[a]
1993	1,377[b]

[a]With 51 from pressurized water reactor.

[b]Fast Flux Test Facility fuel.

- Grout operations--The GTF began operations in September 1988. The waste processing schedule (in millions of gallons of feed processed per year) will be 0.5,0.5,1,1,2,5,5,...

- B Plant pretreatment operations--Scheduled operations for pretreatment of neutralized current acid waste (NCAW) are as follows (Reep 1988):

	Start	Complete
Preparations	4/85	9/92
Demonstration	10/92	9/93
Replace Canyon Crane	9/93	3/94
Process Tank 1 NCAW	4/94	3/96
Process Tank 2 NCAW	4/96	9/98

- Tank farms--AQ Tank Farm is not constructed.

OTHER BASES AND ASSUMPTIONS

- Hanford Waste Vitrification Plant

	Value	Reference
- Yearly output, double-shell tank (DST) waste (canisters)*	145	Wright, G. Pers. Comm.
- Yearly output, single-shell tank (SST) waste (canisters)*	325	Wright, G. Pers. Comm.
- Kilograms glass/glass canister	1,650	Mitchel 1987
- Waste feed oxide loading	25	Mitchel 1987

- Grout--Grout volume calculations assume that the feed is adjusted to 5M Na. The final grout volume is 1.3 times the feed volume.

*Average value assuming 6-mo outage every 3 yr for replacement of glass melter. This value assumes a melter capable of producing 45 kg/h glass for DST waste, and conversion to a 100 kg/h melter for SST wastes. A melter ramp-up schedule is used according to Henderson 1986. Non-base cases assume a 100 kg/h melter is available at startup of HWVP for DST waste, which is equivalent to 320 canisters/year.

Table B-2. Cost Bases and Assumptions--Expense Costs (FY 1988 Dollars). (Sheet 1 of 3)

Parameter	Value	Unit	Reference
B Plant operations			
Neutralized current acid waste pretreatment			
Fiscal Year 1988	22.0	M$/yr	Reep 1988
1989	23.9		
1990	23.8		
1991	30.3		
1992	33.0		
1993	33.1		
1994-1998	33.9		
Cost to ramp down B Plant for shutdown			
Fiscal Year 1988	22.0	M$/yr	Reep 1988
1989	23.9		
1990	19.9		
1991	10.0		
1992	8.0		
Cost to demonstrate pretreatment and generate Waste Form Qualification samples, followed by shutdown			
Fiscal Year 1988	22.0	M$/yr	Reep 1988
1989	24.0		
1990	24.0		
1991	30.0		
1992	33.0		
1993	33.0		
1994	29.0		
1995	18.0		
Cost for B Plant cold shutdown	8.0	M$/yr	Reep 1988
Plutonium Finishing Plant, neutralized cladding removal waste, and neutralized current acid waste transuranic extraction operations	36.2	M$/yr	Place 1988
Complexant concentrate transuranic extraction, and complexant destruction operations	42.1	M$/yr	Place 1988

Table B-2. Cost Bases and Assumptions--Expense Costs (FY 1988 Dollars). (Sheet 2 of 3)

Parameter	Value	Unit	Reference
New stand-alone facility operations			
Neutralized current acid waste, Plutonium Finishing Plant and neutralized cladding removal waste transuranic extraction operations	34.0	M$/yr	Place 1988
Complexant concentrate, transuranic extraction/ complexant destruction operations	40.1	M$/yr	Place 1988
Expanded Hanford Waste Vitrification Plant pretreatment operations[a]			
Neutralized current acid waste, Plutonium Finishing Plant, and neutralized cladding removal waste transuranic extraction	31.9	M$/yr	Place 1988
Complexant concentrate transuranic extraction/ complexant destruction operations	37.8	M$/yr	Place 1988
Hanford Waste Vitrification Plant melter operations			
Double-shell tank waste (45 kg/h)	43.1	M$/yr	Reick 1986
Single-shell tank waste (100 kg/h)	53.8	M$/yr	Reick, pers. comm.
Grout Treatment Facility operations			
Cost per m^3 grout made[b]	.002245	M$/$m^3$	Williamson, pers. Comm.

Table B-2. Cost Bases and Assumptions--Expense Costs (FY 1988 Dollars). (Sheet 3 of 3)

Parameter	Value	Unit	Reference
Repository disposal costs			
High level waste repository, cost per glass canister[c]	0.35	M$/CAN.	Federal Register, 1987
Waste Isolation Pilot Plant, cost per glass canister	0.025	M$/CAN.	Carothers 1987
Waste Isolation Pilot Plant transportation costs			
Cost per glass canister	0.008	M$/CAN.	Carothers 1987
Double-shell tank waste retrieval costs			
Double-shell tank waste retrieval	3.0	M$/tank	Stegen, pers. comm.
In-tank wash operations			
In-tank wash operations	0.0002	$/m^3	Preliminary Estimate

[a] Incremental increase during melter operations.
[b] Includes capital costs for replacement of transportable grout equipment.
[c] Includes transportation costs.

Table B-3. Cost Bases and Assumptions--Capital Costs (FY 1988 Dollars). (Sheet 1 of 2)

Description	Millions	Reference
B Plant Modifications to generate Waste Form Qualification samples (no crane)	70.0	Reep, pers. comm.
B Plant modifications cost with no further operations	28.0	Reep 1988
B Plant modifications, 2 tanks neutralized current acid waste	93.0	Reep 1988
B Plant modifications, dissolution, transuranic extraction	67.0	Rode 1988
B Plant modifications, extra-capacity dissolution, transuranic extraction	100.0	Rode, pers. comm.
B Plant post 2000 capital costs		
Double-shell tank only	26.0	Reep, pers. comm.
Double-shell tank, 12 single-shell tanks	42.0	Reep, pers. comm.
Double-shell tank, 75 single-shell tanks	69.0	Reep, pers. comm.
Double-shell tank, 149 single-shell tanks	92.0	Reep, pers. comm.
New stand-alone facility	242.0	Garfield 1988
New facility post 2000 capital cost		
All double-shell tank only	12.3	Reep, pers. comm.
Double-shell tank, no neutralized current acid waste	7.3	Reep, pers. comm.
All double-shell tank, 12 single-shell tanks	15.8	Reep, pers. comm.
All double-shell tank, 75 single-shell tanks	42.0	Reep, pers. comm.
All double-shell tank, 149 single-shell tanks	58.0	Reep, pers. comm.

Table B-3. Cost Bases and Assumptions--Capital Costs (FY 1988 Dollars). (Sheet 2 of 2)

Description	Millions	Reference
Expanded Hanford Waste Vitrification Plant (pretreatment only)	162.0	Garfield 1988
PUREX pretreatment	140.0	Preliminary estimate
Rework preliminary Hanford Waste Vitrification Plant design	7.0	Garfield 1988
Upgrade waste transfer line	29.0	Diliberto, pers. comm.

Table B-4. Current Baseline (Case A) Capital Costs.

ASSUMPTIONS CASE A	CASE A CAPITAL COSTS	APPLIES TO THIS CASE?	MILLIONS
GENERAL:			
ALL PRETREATMENT AT 8 PLANT.	8 PLANT UPGRADES, DEMO ONLY		70
USES REF.PRETR. PROCESSES.	FULL 8 PLANT UPGRADES	YES	93
PROCESS NO SST	8 PLANT MOD,DISS.,TRUEX	YES	67
45 KG/HR MELTER	8 PLANT MOD,EXTRA CAPACITY DISS,TRUEX		100
	8 PLANT POST 2000 CAPITAL COSTS		
SPECIFIC:	OST ONLY	YES	26
	OST, 12 SST		42
PRETREATMENT PROCESS	OST, 75 SST		63
-NCAW, SLS/SW	OST, 149 SST		92
-PFP, DISS/ TRUEX	NEW STAND-ALONE FACILITY		242
-CC, TRUEX/CD	NEW FACILITY POST 2000 CAPITAL COST		
-NCRW, DISS/TRUEX	ALL OST ONLY		12.3
-SST	OST, NO NCAW		7.3
	ALL OST, 12 SST		15.8
PRETREATMENT THROUGHPUT	ALL OST, 75 SST		42
PFP- 25 MO	ALL OST, 149 SST		58
CC- 46 MO	HWVP, MID POINT CONSTR.	YES	920
NCRW- 51 MO	EXPANDED HWVP		182
NCAW-54 MO	REWORK PRELIM HWVP DESIGN		7
SST-	UPGRADE WASTE TRANSFER LINE	YES	29
IMMOBILIZATION THROUGHPUT	TOTAL CAPITAL FOR THIS CASE	1135	
GLASS HWVP			
NCAW-39 MO			
CC-41 MO			
PFP-7 MO			
NCRW-29 MO			
SST-			
DISPOSAL			
HLW REP.			
-PFP			
-CC			
-NCRW			
-SST			
WIPP			
-NONE			
GLASS CANISTERS-			
NCAW- 485			
CC- 580			
NCRW- 400			
PFP- 100			
SST-			
LLW GROUT VOLUMES-			
CC-74000 m3			
NCRW-9800 m3			
PFP-2100 m3			
SST-0 m3			
NCAW-14000 m3			

Table B-5. Current Baseline (Case A)--Yearly Operating Costs.

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
B PLANT OPERATIONS	22.0	23.9	23.0	30.4	33.0	33.1	33.9	33.9	33.9	33.9	31.9	33.9
NEW FACILITY OPERATIONS												
GTF OPERATIONS												
HWVP OPERATIONS											3.3	43.1
MISCELLANEOUS												
SHIPPING AND REPOSITORY DISPOSAL												
ANNUAL TOTAL DISPOSAL OPERATIONS	22.0	23.9	23.0	30.4	33.0	33.1	33.9	33.9	33.9	33.9	66.2	77.0
TOTAL CUMULATIVE	22.5	46.4	69.2	100.5	133.5	166.6	200.5	234.4	268.3	302.2	368.4	445.4

NOTE: MISC. COSTS = WASTE RETRIEVAL, IN-TANK MIXING, WASTE EVAPORATION, AND TECH. DEV.

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
B PLANT OPERATIONS	37.3	40.7	40.7	40.7	37.6	36.0	36.0	36.0	36.0	36.0	34.1	17.6
NEW FACILITY OPERATIONS												
GTF OPERATIONS												
HWVP OPERATIONS	43.1	43.1	43.1	43.1	43.1	43.1	43.1	43.1	43.1	43.1	43.1	43.1
MISCELLANEOUS												
SHIPPING AND REPOSITORY DISPOSAL												
ANNUAL TOTAL DISPOSAL OPERATIONS	80.4	83.8	83.8	83.8	80.7	79.1	79.1	79.1	79.1	79.1	77.2	60.7
TOTAL CUMULATIVE	525.8	609.6	693.4	777.2	857.9	937.0	1016.1	1095.2	1174.3	1253.4	1330.6	1391.3

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	TOTALS
B PLANT OPERATIONS	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	800.7
NEW FACILITY OPERATIONS												
GTF OPERATIONS												171.8
HWVP OPERATIONS	41.1	10.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	653.7
MISCELLANEOUS												72.0
SHIPPING AND REPOSITORY DISPOSAL												547.8
ANNUAL TOTAL DISPOSAL OPERATIONS	43.6	10.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
TOTAL CUMULATIVE	1434.7	1445.1	1445.1	1445.1	1445.1	1445.1	1445.1	1445.1	1445.1	1445.1	1445.1	2240.9

Table B-6. Current Baseline (Case C 100 kg/h Melter) Capital Costs.

ASSUMPTIONS CASE C	CASE C CAPITAL COSTS	APPLIES TO THIS CASE?	COST MILLIONS
GENERAL:			
ALL PRETREATMENT AT B PLANT.	B PLANT UPGRADES, DEMO ONLY		70
USES REF.PRETR. PROCESSES.	FULL B PLANT UPGRADES	YES	93
PROCESS NO SST	B PLANT MOD,DISS.,TRUEX		87
100 KG/HR MELTER	B PLANT MOD,EXTRA CAPACITY DISS,TRUEX	YES	100
EXPANDED DISSOLUTION CAPACITY	B PLANT POST 2000 CAPITAL COSTS		
	OST ONLY	YES	26
SPECIFIC:	OST, 12 SST		42
	OST, 75 SST		69
PRETREATMENT PROCESS	OST, 149 SST		92
-NCAW, SLS/SW	NEW STAND-ALONE FACILITY		242
-PFP, DISS/ TRUEX	NEW FACILITY POST 2000 CAPITAL COST		
-CC, TRUEX/CD	ALL OST ONLY		12.3
-NCRW, DISS/TRUEX	OST, NO NCAW		7.3
-SST	ALL OST, 12 SST		15.8
	ALL OST, 75 SST		42
PRETREATMENT THROUGHPUT	ALL OST, 149 SST		58
PFP- 13 MO	HWVP, MID POINT CONSTR.	YES	920
CC- 35 MO	EXPANDED HWVP		162
NCRW- 23 MO	REWORK PRELIM HWVP DESIGN		7
NCAW-54 MO	UPGRADE WASTE TRANSFER LINE	YES	29
SST-			
	TOTAL CAPITAL FOR THIS CASE	1168	
IMMOBILIZATION THROUGHPUT			
GLASS HWVP			
NCAW-20 MO			
CC-19 MO			
PFP-3 MO			
NCRW-13 MO			
SST-			
DISPOSAL			
HLW REP.			
-PFP			
-CC			
-NCRW			
-SST			
WIPP			
-NONE			
GLASS CANISTERS-			
NCAW- 485			
CC- 580			
NCRW- 400			
PFP- 100			
SST-			
LLW GROUT VOLUMES-			
CC-74000 m3			
NCRW-9800 m3			
PFP-2100 m3			
SST-0 m3			
NCAW-14000 m3			

Table B-7. Current Baseline (Case C 100kg/h Melter) Yearly Operating Costs.

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
B PLANT OPERATIONS	22.0	23.9	23.0	30.7	45.0	33.1	31.9	33.9	33.9	33.9	33.9	33.9
NEW FACILITY OPERATIONS												
GTF OPERATIONS												
HWVP OPERATIONS											40.1	53.8
MISCELLANEOUS												
SHIPPING AND REPOSITORY DISPOSAL												
ANNUAL TOTAL DISPOSAL OPERATIONS	22.0	23.9	23.0	30.7	49.0	33.1	31.9	33.9	33.9	33.9	74.3	87.7
TOTAL CUMULATIVE	22.0	45.9	69.7	100.0	149.0	166.1	200.0	233.9	267.8	301.7	376.0	463.7

NOTE: MISC. COSTS = WASTE RETRIEVAL, IN-TANK MIXING, WASTE EVAPORATION, AND TECH. DEV.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
B PLANT OPERATIONS	30.0	42.1	42.1	38.5	30.1	30.2	27.8	21.5	6.3	0.0	0.0	0.0
NEW FACILITY OPERATIONS												
GTF OPERATIONS												
HWVP OPERATIONS	53.0	53.8	53.0	53.0	53.0	53.0	53.0	49.3				
MISCELLANEOUS												
SHIPPING AND REPOSITORY DISPOSAL												
ANNUAL TOTAL DISPOSAL OPERATIONS	91.0	95.9	95.9	92.3	83.9	83.0	80.6	70.9	6.3	0.0	0.0	0.0
TOTAL CUMULATIVE	555.5	651.4	747.2	839.6	923.5	1006.5	1087.1	1157.0	1163.3	1163.3	1163.3	1163.3

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	TOTALS
B PLANT OPERATIONS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	663.2
NEW FACILITY OPERATIONS												174.8
GTF OPERATIONS												
HWVP OPERATIONS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	520.1
MISCELLANEOUS												72.0
SHIPPING AND REPOSITORY DISPOSAL												547.0
ANNUAL TOTAL DISPOSAL OPERATIONS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
TOTAL CUMULATIVE	1163.3	1163.3	1163.3	1163.3	1163.3	1163.3	1163.3	1163.3	1163.3	1163.3	1163.3	1977.0

Table B-8. Preferred Option (Case G) Capital Costs.

ASSUMPTIONS CASE G	CASE G CAPITAL COSTS	APPLIES TO THIS CASE?	COST MILLIONS
GENERAL:			
WASH NCAW IN DST	B PLANT UPGRADES, DEMO ONLY		70
TRUEX REMAINDER AT B PLANT.	FULL B PLANT UPGRADES	YES	93
USES REF.PRETR. PROCESSES.	B PLANT MOD,DISS.,TRUEX		67
PROCESS NO SST	B PLANT MOD,EXTRA CAPACITY DISS,TRUEX	YES	100
100 KG/HR MELTER	B PLANT POST 2000 CAPITAL COSTS		
EXPANDED DISSOLUTION CAPACITY	DST ONLY	YES	26
	DST, 12 SST		42
SPECIFIC:	DST, 75 SST		69
	DST, 149 SST		92
PRETREATMENT PROCESS	NEW STAND-ALONE FACILITY		242
-NCAW, SLS/SW	NEW FACILITY POST 2000 CAPITAL COST		
-PFP, DISS/ TRUEX	ALL DST ONLY		12.3
-CC, TRUEX/CD	DST, NO NCAW		7.3
-NCRW, DISS/TRUEX	ALL DST, 12 SST		15.8
-SST	ALL DST, 75 SST		42
	ALL DST, 149 SST		58
PRETREATMENT THROUGHPUT	HWVP, MID POINT CONSTR.	YES	920
PFP- 13 MO	EXPANDED HWVP		162
CC- 35 MO	REWORK PRELIM HWVP DESIGN		7
NCRW- 23 MO	UPGRADE WASTE TRANSFER LINE	YES	29
NCAW-0 MO			
SST-	TOTAL CAPITAL FOR THIS CASE	1168	

IMMOBILIZATION THROUGHPUT
- GLASS HWVP
  - NCAW-20 MO
  - CC-19 MO
  - PFP-3 MO
  - NCRW-13 MO
  - SST-

DISPOSAL
- HLW REP.
  - -PFP
  - -CC
  - -NCRW
  - -SST
- HIPP
  - -NONE

GLASS CANISTERS-
NCAW- 485
CC- 580
NCRW- 400
PFP- 100
SST-

LLW GROUT VOLUMES-
CC-74000 m3
NCRW-9800 m3
PFP-2100 m3
SST-0 m3
NCAW-14000 m3

Table B-9. Preferred Option (Case G) Yearly Operating Costs.

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
B PLANT OPERATIONS	22.0	23.9	23.0	30.7	11.0	11.1	29.0	29.0	33.9	35.0	36.0	36.0
NEW FACILITY OPERATIONS												
GIF OPERATIONS												
HWVP OPERATIONS											40.4	53.8
MISCELLANEOUS												
SHIPPING AND REPOSITORY DISPOSAL												
ANNUAL TOTAL DISPOSAL OPERATIONS	22.0	23.9	23.0	30.7	11.0	11.1	29.0	29.0	33.9	35.0	76.4	89.8
TOTAL CUMULATIVE	22.0	45.9	68.7	100.0	111.0	122.1	151.9	180.9	214.8	249.8	326.2	416.0

NOTE: MISC. COSTS = WASTE RETRIEVAL, [illegible],
WASTE EVAPORATION, AND TECH. DEV.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
B PLANT OPERATIONS	39.1	42.1	42.1	18.2	25.0	12.0	0.0	0.0	0.0	0.0	0.0	0.0
NEW FACILITY OPERATIONS												
GIF OPERATIONS												
HWVP OPERATIONS	53.8	53.8	53.8	53.8	41.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MISCELLANEOUS												
SHIPPING AND REPOSITORY DISPOSAL												
ANNUAL TOTAL DISPOSAL OPERATIONS	92.9	95.9	95.9	72.0	66.0	12.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL CUMULATIVE	553.5	649.4	745.3	817.3	883.3	895.3	919.1	919.1	919.1	919.1	919.1	919.1

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	TOTALS
B PLANT OPERATIONS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	565.0
NEW FACILITY OPERATIONS												
GIF OPERATIONS												174.8
HWVP OPERATIONS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	354.2
MISCELLANEOUS												72.0
SHIPPING AND REPOSITORY DISPOSAL												547.8
ANNUAL TOTAL DISPOSAL OPERATIONS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
TOTAL CUMULATIVE	919.1	919.1	919.1	919.1	919.1	919.1	919.1	919.1	919.1	919.1	919.1	1713.7

Table B-10. Comparison of Double-Shell Tank Pretreatment Alternatives. (Sheet 1 of 19)

Description of Alternative: Case A Current Baseline (See Appendix D)
Sludge wash NCAW at B Plant
TRUEX remaining waste at B Plant
45 kg/h melter

Cost Element	Total Lifecycle Cost, $Millions Baseline	Alternative	Δ
Pretreatment Capital	186		
Pretreatment Oper.	801		
B Plant Standby	0		
Vitrification Oper.	654		
Grout	175		
Repository	548		
HWVP Capital	920		
Miscellaneous	102		
Total	3390		
Year			
Pretreatment Start	4/94		
Pretreatment Compl.	6/10		
Vitrification Start	7/99		
Vitrification Compl.	2/13		

Table B-10. Comparison of Double-Shell Tank Pretreatment Alternatives. (Sheet 2 of 19)

Description of Alternative: Case B (See Appendix D)
Wash NCAW at B Plant
CC-Complexant destruction B Plant
In-tank wash PFP & NCRW
100 kg/h melter

Cost Element	Total Lifecycle Cost, $Millions Baseline	Alternative	Δ
Pretreatment Capital	186	135	(51)
Pretreatment Oper.	801	742	59
B Plant Standby	0	0	0
Vitrification Oper.	654	657	(3)
Grout	175	130	45
Repository	548	1170	(622)
HWVP Capital	920	920	0
Miscellaneous	102	82	20
Total	3390	3830	(450)
Year			
Pretreatment Start	4/94	4/94	
Pretreatment Compl.	6/10	8/07	
Vitrification Start	7/99	7/99	
Vitrification Compl.	2/13	3/07	

Table B-10. Comparison of Double-Shell Tank Pretreatment Alternatives. (Sheet 3 of 19)

Description of Alternative: Case C (See Appendix D)
Sludge wash NCAW at B Plant
TRUEX remaining waste at B Plant (expanded capacity)
100 kg/h melter

Cost Element	Total Lifecycle Cost, $Millions Baseline	Alternative	Δ
Pretreatment Capital	186	219	(33)
Pretreatment Oper.	801	663	138
B Plant Standby	0	0	0
Vitrification Oper.	654	520	134
Grout	175	175	0
Repository	548	548	0
HWVP Capital	920	920	0
Miscellaneous	102	102	0
Total	3390	3150	240
Year			
Pretreatment Start	4/94	4/94	
Pretreatment Compl.	6/10	3/06	
Vitrification Start	7/99	7/99	
Vitrification Compl.	2/13	9/07	

Table B-10. Comparison of Double-Shell Tank Pretreatment Alternatives. (Sheet 4 of 19)

Description of Alternative: Case D (See Appendix D)
In-tank wash PFP
B Plant TRUEX remaining waste
100 kg/h melter

Cost Element	Total Lifecycle Cost, $Millions Baseline	Alternative	△
Pretreatment Capital	186	216	(30)
Pretreatment Oper.	801	554	247
B Plant Standby	0	0	0
Vitrification Oper.	654	350	304
Grout	175	180	(5)
Repository	548	525	23
HWVP Capital	920	920	0
Miscellaneous	102	102	0
Total	3390	2850	540
Year			
Pretreatment Start	4/94	4/97	
Pretreatment Compl.	6/10	4/03	
Vitrification Start	7/99	7/99	
Vitrification Compl.	2/13	8/04	

Table B-10. Comparison of Double-Shell Tank Pretreatment Alternatives. (Sheet 5 of 19)

Description of Alternative: Case E (See Appendix D)
In-tank wash NCAW, NCRW & PFP
CC-Complexant destruction at B Plant
100 kg/h melter

Cost Element	Total Lifecycle Cost, $Millions Baseline	Alternative	Δ
Pretreatment Capital	186	134	(52)
Pretreatment Oper.	801	582	219
B Plant Standby	0	0	0
Vitrification Oper.	654	651	3
Grout	175	130	45
Repository	548	1170	(622)
HWVP Capital	920	920	0
Miscellaneous	102	82	20
Total	3390	3670	(280)
Year			
Pretreatment Start	4/94	4/97	
Pretreatment Compl.	6/10	4/05	
Vitrification Start	7/99	7/99	
Vitrification Compl.	2/13	3/10	

Table B-10. Comparison of Double-Shell Tank Pretreatment Alternatives. (Sheet 6 of 19)

Description of Alternative: Case F (See Appedix D)
In-tank wash NCAW, PFP & NCRW
CC-Complexant destruction in DST
100 kg/h melter

Cost Element	Total Lifecycle Cost, $Millions Baseline	Alternative	Δ
Pretreatment Capital	186	150	(36)
Pretreatment Oper.	801	213	588
B Plant Standby	0	112	(112)
Vitrification Oper.	654	651	3
Grout	175	130	45
Repository	548	1170	(622)
HWVP Capital	920	920	0
Miscellaneous	102	82	20
Total	3390	3430	(40)

Year		
Pretreatment Start	4/94	a
Pretreatment Compl.	6/10	a
Vitrification Start	7/99	7/99
Vitrification Compl.	2/13	3/05

Other Considerations

(a) Sludge washing and C.D. performed in DSTs approximately FY95-FY 2005 time frame.

Table B-10. Comparison of Double-Shell Tank Pretreatment Alternatives. (Sheet 7 of 19)

Description of Alternative: Case G (See Appedix D)
In-tank wash NCAW
TRUEX remainder B Plant
100 kg/h melter

Cost Element	Total Lifecycle Cost, $Millions Baseline	Alternative	Δ
Pretreatment Capital	186	219	(33)
Pretreatment Oper.	801	565	236
B Plant Standby	0	0	0
Vitrification Oper.	654	354	300
Grout	175	175	0
Repository	548	546	2
HWVP Capital	920	920	0
Miscellaneous	102	102	0
Total	3390	2880	510
Year			
Pretreatment Start	4/94	4/97	
Pretreatment Compl.	6/10	3/03	
Vitrification Start	7/99	7/99	
Vitrification Compl.	2/13	2/05	

Table B-10. Comparison of Double-Shell Tank Pretreatment Alternatives. (Sheet 8 of 19)

Description of Alternative: CASE G WITH 6430.1A UPGRADES
In-tank wash NCAW
TRUEX remainder B Plant (6430.1A Upgrades)
100 kg/h melter

Cost Element	Total Lifecycle Cost, $Millions Baseline	Alternative	△
Pretreatment Capital	186	379	(193)
Pretreatment Oper.	801	641	160
B Plant Standby	0	0	0
Vitrification Oper.	654	503	151
Grout	175	175	0
Repository	548	548	0
HWVP Capital	920	920	0
Miscellaneous	102	102	0
Total	3390	3270	120
Year			
Pretreatment Start	4/94	4/00	
Pretreatment Compl.	6/10	3/06	
Vitrification Start	7/99	7/99	
Vitrification Compl.	2/13	5/07	

Table B-10. Comparison of Double-Shell Tank Pretreatment Alternatives. (Sheet 9 of 19)

Description of Alternative: Case H (See Appendix D)
Wash NCAW in B Plant
TRUEX remainder in expanded HWVP
100 kg/h melter

Cost Element	Total Lifecycle Cost, $Millions Baseline	Alternative	Δ
Pretreatment Capital	186	270	(84)
Pretreatment Oper.	801	593	208
B Plant Standby	0	28	(28)
Vitrification Oper.	654	354	300
Grout	175	175	0
Repository	548	546	2
HWVP Capital	920	920	0
Miscellaneous	102	102	0
Total	3390	2990	400
Year			
Pretreatment Start	4/94	4/94	
Pretreatment Compl.	6/10	9/03	
Vitrification Start	7/99	3/00	
Vitrification Compl.	2/13	4/05	

Table B-10. Comparison of Double-Shell Tank Pretreatment Alternatives. (Sheet 10 of 19)

Description of Alternative: Case I (See Appendix D)
Wash NCAW in DST
TRUEX rest HWVP Expansion
100 kg/h melter

Cost Element	Total Lifecycle Cost, $Millions Baseline	Alternative	Δ
Pretreatment Capital	186	246	(60)
Pretreatment Oper.	801	427	374
B Plant Standby	0	73	(73)
Vitrification Oper.	654	354	300
Grout	175	180	(5)
Repository	548	547	1
HWVP Capital	920	920	0
Miscellaneous	102	102	0
Total	3390	2850	540
Year			
Pretreatment Start	4/94	1/00	
Pretreatment Compl.	6/10	9/03	
Vitrification Start	7/99	5/00	
Vitrification Compl.	2/13	6/05	

Table B-10. Comparison of Double-Shell Tank Pretreatment Alternatives. (Sheet 11 of 19)

Description of Alternative: Alternative Case I (See Appendix D)
Wash NCAW in DST
TRUEX remainder in new stand-alone facility
100 kg/h melter

Cost Element	Total Lifecycle Cost, $Millions Baseline	Alternative	Δ
Pretreatment Capital	186	319	(133)
Pretreatment Oper.	801	424	377
B Plant Standby	0	72	(72)
Vitrification Oper.	654	444	210
Grout	175	175	0
Repository	548	548	0
HWVP Capital	920	920	0
Miscellaneous	102	102	0
Total	3390	3000	390
Year			
Pretreatment Start	4/94	1/01	
Pretreatment Compl.	6/10	9/04	
Vitrification Start	7/99	7/99	
Vitrification Compl.	2/13	4/06	

Table B-10. Comparison of Double-Shell Tank Pretreatment Alternatives. (Sheet 12 of 19)

Description of Alternative: Alternate Case I (See Appendix D)
Wash NCAW in DST
TRUEX remainder at PUREX
100 kg/h melter

Cost Element	Total Lifecycle Cost, $Millions Baseline	Alternative	Δ
Pretreatment Capital	186	222	(36)
Pretreatment Oper.	801	543	258
B Plant Standby	0	60	(60)
Vitrification Oper.	654	354	300
Grout	175	175	0
Repository	548	548	0
HWVP Capital	920	920	0
Miscellaneous	102	102	0
Total	3390	2930	460
Year			
Pretreatment Start	4/94	4/97	
Pretreatment Compl.	6/10	3/03	
Vitrification Start	7/99	7/99	
Vitrification Compl.	2/13	8/04	

Table B-10. Comparison of Double-Shell Tank Pretreatment Alternatives. (Sheet 13 of 19)

Description of Alternative
PFP washed in-tank
TRUEX remainder in new stand-alone facility
100 kg/h melter

Cost Element	Total Lifecycle Cost, $Millions Baseline	Alternative	Δ
Pretreatment Capital	186	319	(133)
Pretreatment Oper.	801	427	374
B Plant Standby	0	72	(72)
Vitrification Oper.	654	444	210
Grout	175	180	(5)
Repository	548	525	23
HWVP Capital	920	920	0
Miscellaneous	102	102	0
Total	3390	2990	400
Year			
Pretreatment Start	4/94	2/01	
Pretreatment Compl.	6/10	10/04	
Vitrification Start	7/99	7/99	
Vitrification Compl.	2/13	4/06	

Table B-10. Comparison of Double-Shell Tank Pretreatment Alternatives. (Sheet 14 of 19)

Description of Alternative
PFP washed in DST
TRUEX remainder in expanded HWVP
100 kg/h melter

Cost Element	Total Lifecycle Cost, $Millions Baseline	Alternative	Δ
Pretreatment Capital	186	246	(60)
Pretreatment Oper.	801	427	374
B Plant Standby	0	73	(73)
Vitrification Oper.	654	354	300
Grout	175	180	5
Repository	548	525	23
HWVP Capital	920	920	0
Miscellaneous	102	102	0
Total	3390	2830	560

Year		
Pretreatment Start	4/94	1/00
Pretreatment Compl.	6/10	10/03
Vitrification Start	7/99	3/00
Vitrification Compl.	2/13	4/05

Table B-10. Comparison of Double-Shell Tank Pretreatment Alternatives. (Sheet 15 of 19)

Description of Alternative
Wash PFP in tank
TRUEX remainder at PUREX
100 kg/h melter

Cost Element	Total Lifecycle Cost, $Millions Baseline	Alternative	△
Pretreatment Capital	186	220	(34)
Pretreatment Oper.	801	546	255
B Plant Standby	0	48	(48)
Vitrification Oper.	654	355	299
Grout	175	180	(5)
Repository	548	525	23
HWVP Capital	920	920	0
Miscellaneous	102	102	0
Total	3390	2900	490

Year		
Pretreatment Start	4/94	6/97
Pretreatment Compl.	6/10	4/03
Vitrification Start	7/99	7/99
Vitrification Compl.	2/13	8/04

Table B-10. Comparison of Double-Shell Tank Pretreatment Alternatives. (Sheet 16 of 19)

Description of Alternative
B Plant all waste
TRUEX all waste
100 kg/h Equiv.

Cost Element	Total Lifecycle Cost, $Millions Baseline	Alternative	△
Pretreatment Capital	186	216	(30)
Pretreatment Oper.	801	600	201
B Plant Standby	0	0	0
Vitrification Oper.	654	310	344
Grout	175	185	(10)
Repository	548	420	128
HWVP Capital	920	920	0
Miscellaneous	102	102	0
Total	3390	2750	640
Year			
Pretreatment Start	4/94	4/97	
Pretreatment Compl.	6/10	7/04	
Vitrification Start	7/99	7/01	
Vitrification Compl.	2/13	11/04	

Table B-10. Comparison of Double-Shell Tank Pretreatment Alternatives. (Sheet 17 of 19)

Description of Alternative
New stand-alone all waste
TRUEX all waste
100 kg/h melter

Cost Element	Total Lifecycle Cost, $Millions Baseline	Alternative	△
Pretreatment Capital	186	324	(138)
Pretreatment Oper.	801	457	344
B Plant Standby	0	96	(96)
Vitrification Oper.	654	305	349
Grout	175	185	(10)
Repository	548	420	128
HWVP Capital	920	920	0
Miscellaneous	102	102	0
Total	3390	2810	580
Year			
Pretreatment Start	4/94	1/99	
Pretreatment Compl.	6/10	8/03	
Vitrification Start	7/99	2/01	
Vitrification Compl.	2/13	4/05	

Table B-10. Comparison of Double-Shell Tank Pretreatment Alternatives. (Sheet 18 of 19)

Description of Alternative
Expanded HWVP all waste
TRUEX all waste
100 kg/h melter

Cost Element	Total Lifecycle Cost, $Millions Baseline	Alternative	△
Pretreatment Capital	186	251	(65)
Pretreatment Oper.	801	449	352
B Plant Standby	0	104	(104)
Vitrification Oper.	654	305	349
Grout	175	185	(10)
Repository	548	420	128
HWVP Capital	920	920	0
Miscellaneous	102	102	0
Total	3390	2740	650
Year			
Pretreatment Start	4/94	1/00	
Pretreatment Compl.	6/10	8/04	
Vitrification Start	7/99	2/02	
Vitrification Compl.	2/13	4/06	

Table B-10. Comparison of Double-Shell Tank Pretreatment Alternatives. (Sheet 19 of 19)

Description of Alternative
PUREX all waste
TRUEX all waste
100 kg/h melter

Cost Element	Total Lifecycle Cost, $Millions Baseline	Alternative	△
Pretreatment Capital	186	220	(34)
Pretreatment Oper.	801	585	216
B Plant Standby	0	56	(656)
Vitrification Oper.	654	310	344
Grout	175	185	(10)
Repository	548	420	128
HWVP Capital	920	920	0
Miscellaneous	102	102	0
Total	3390	2800	590

Year		
Pretreatment Start	4/94	4/97
Pretreatment Compl.	6/10	7/04
Vitrification Start	7/99	7/01
Vitrification Compl.	2/13	11/04

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APPENDIX C

DISCOUNT RATE ANALYSIS

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APPENDIX C

DISCOUNT RATE ANALYSIS

Although a constant dollar analysis does not account for the value of borrowing or investing money, it is an appropriate method for making the comparisons presented in this study. This conclusion is illustrated by applying a discount rate analysis to selected pretreatment options. The discount rate accounts for the cost of borrowing money for federal projects as well as the cost of opportunities of other investments. Recommended discount rates by the Federal Government are 10% (U.S. Department of Commerce 1987). Accounting for 7% escalation, which is appropriate when applying a discount rate analysis using constant 1988 dollars, results in a differential rate of up to 3%. Table C-1 shows the total net present value of each option at various differential rates. The 3% differential rate represents the most realistic case, whereas the 10% differential rate is intended to simply provide a sensitivity comparison. Even though the conclusions provided in this document are based on a constant dollar analysis, it is evident that application of the discount rate analysis will not affect them. For instance, the constant dollar analysis indicates the least costly option for disposal in a high-level waste repository is to wash NCAW in a DST and apply the TRUEX process to the remaining waste. The same conclusion is reached by applying a 3% differential rate. Even if the Waste Isolation Pilot Plant (WIPP) becomes available, the net present value is equivalent to the in-tank sludge washing case. Even applying an unrealistic differential rate of 10% does not provide a significant incentive to prefer in tank washing of all sludge to the TRUEX process option with HLW repository disposal. Since these illustrated cases represent the extremes in differences in capital investments and do not change the overall conclusions, it is concluded that the constant dollar analysis is appropriate for comparing costs of the various pretreatment options.

Table C-1. Comparison of Selected Pretreatment Options at Various Differentials Between the Discount Rate and Escalation ($ Million).

Differential rate	Current baseline-wash NCAW B Plant TRUEX remainder B Plant 45 kg/h melter	Wash NCAW in DST; TRUEX remainder in B Plant[a]		Sludge wash all waste in DST compl. detr. on CC in DST[a]	
		HLW repository disposal	WIPP disposal[c]	HLW repository disposal	WIPP disposal[c]
0%[b] (constant dollar)	3,400	2,900	2,750	3,400	2,800
3%	2,200	2,000	1,900	2,200	1,850
10%	1,150	1,100	1,050	1,050	950

[a]Assumes use of 100 kg/h melter at HWVP.

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[b]HWVP costs are escalated to midpoint of construction.

[c]Assumes glass made from NCRW and PFP waste can be disposed of at the Waste Isolation Pilot Plant (WIPP). See Section 6.0 for additional details on WIPP disposal options.

C.1 REFERENCES

U.S. Department of Commerce, 1987, *Life Cycle Costs Manual for the Federal Energy Management Program*, NBS Handbook 135, Washington, D.C.

APPENDIX D

DECISION ANALYSIS

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APPENDIX D

DECISION ANALYSIS

A decision analysis procedure was used to arrive at the preferred double-shell tank (DST) waste pretreatment plan. A logic tree (Figure D-1) graphically depicts on a time scale, the technical and programmatic decisions necessary to arrive at a viable DST pretreatment system. The alternate paths through the logic tree result in process and facility options described in this report. A narrative description for each decision point is provided. Technology development requirements necessary for each decision point are identified in the description. The decision analysis options support a 1999 Hanford Waste Vitrification Plant (HWVP) startup. A bold line indicates the "preferred option" chosen for low cost and minimal technological uncertainties. The issues or decision points must be resolved to confirm the preferred option.

The following narrative descriptions correspond to the numbered decision points in the logic tree (Figure D-1). The alternate paths through the logic tree result in nine process and facility options (Case A through I).

1. Can a throughput capacity of 100 kg glass per hour for the HWVP melter be utilized for DST wastes, and can pretreatment facility feed throughput rates be adjusted to match these rates to the maximum extent possible?

   The increase in throughput capacity for both pretreatment and vitrification has been shown to be cost effective. Installation of appropriate B Plant equipment to achieve the maximum possible throughput and utilization of the 100 kg/h melter (Case C) results in a minimum $250 million savings over the baseline pretreatment Case A (i.e., smaller sized B Plant equipment and use of a 45 kg/h melter). The maximum achievable throughput capacity in B Plant must be determined. The recommendation to increase B Plant

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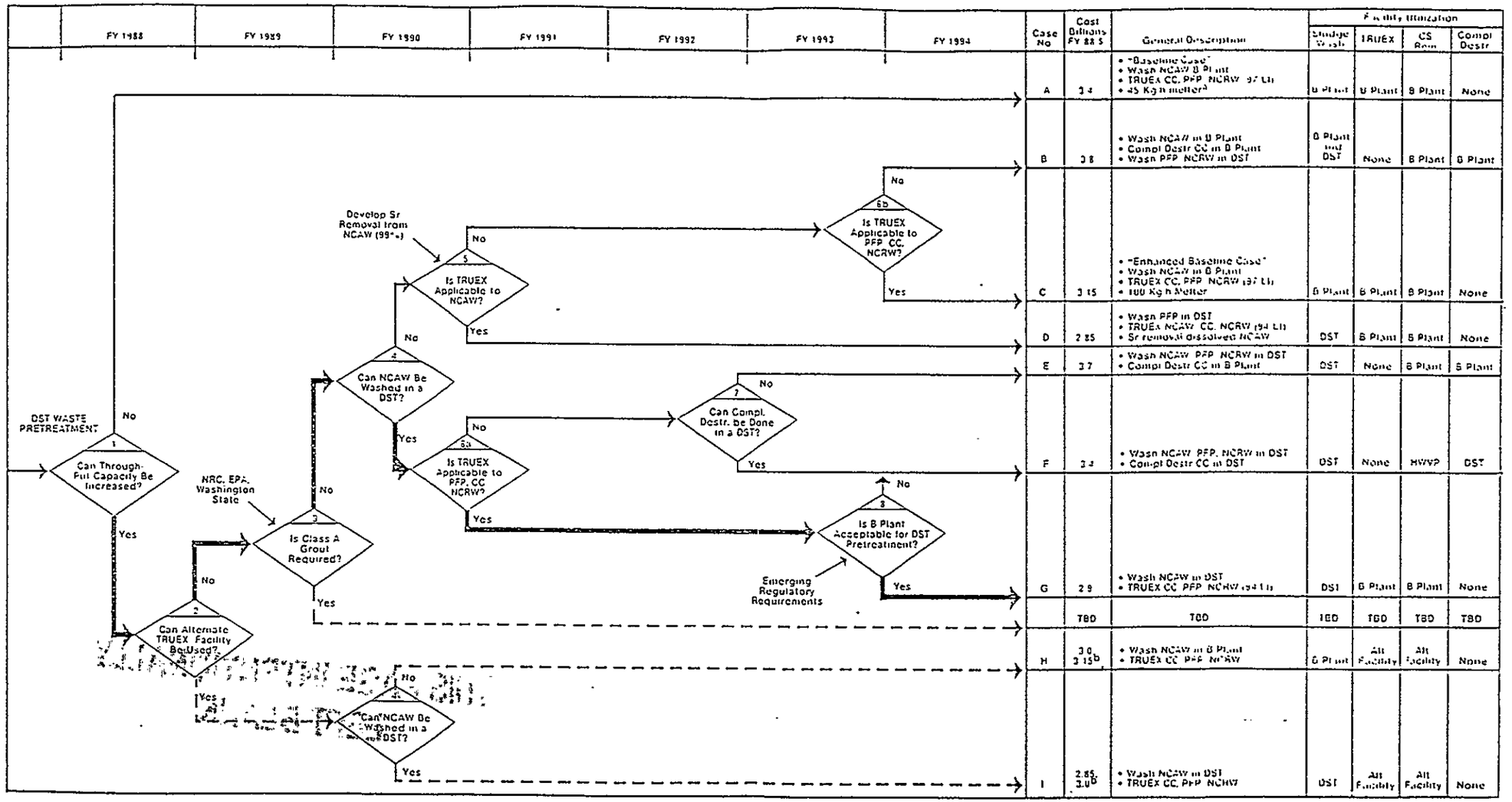

Case No	Cost Billions FY 88 $	General Description	Facility Utilization: Sludge Wash	TRUEX	CS Rem	Compl Destr
A	3.4	• "Baseline Case" • Wash NCAW in B Plant • TRUEX CC, PFP, NCRW (97 Li) • 45 Kg/h melter[a]	B Plant	B Plant	B Plant	None
B	3.8	• Wash NCAW in B Plant • Compl Destr CC in B Plant • Wash PFP NCRW in DST	B Plant and DST	None	B Plant	B Plant
C	3.15	• "Enhanced Baseline Case" • Wash NCAW in B Plant • TRUEX CC, PFP, NCRW (97 Li) • 100 Kg/h Melter	B Plant	B Plant	B Plant	None
D	2.85	• Wash PFP in DST • TRUEX NCAW, CC, NCRW (94 Li) • Sr removal dissolved NCAW	DST	B Plant	B Plant	None
E	3.7	• Wash NCAW, PFP, NCRW in DST • Compl Destr CC in B Plant	DST	None	B Plant	B Plant
F	3.4	• Wash NCAW, PFP, NCRW in DST • Compl Destr CC in DST	DST	None	HWVP	DST
G	2.9	• Wash NCAW in DST • TRUEX CC, PFP, NCRW (94 Li)	DST	B Plant	B Plant	None
	TBD	TBD	TBD	TBD	TBD	TBD
H	3.0 3.15[b]	• Wash NCAW in B Plant • TRUEX CC, PFP, NCRW	B Plant	All Facility	All Facility	None
I	2.85 3.0[b]	• Wash NCAW in DST • TRUEX CC, PFP, NCRW	DST	All Facility	All Facility	None

NOTE: To simplify the Logic Diagram, paths not fully defined due to scheduler constraints or technical uncertainties, are indicated by dashed lines.
[a]All remaining cases assume use of 100 kg/h melter.
TBD = To be determined
[b]Costs for expanded HWVP and new stand alone pretreatment facilities, respectively

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Figure D-1. Double-Shell Ta
Pretreatment Decision Analysi
1999 Hanford Waste Vitrificat
Plant Startup.

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pretreatment capacity to the maximum extent possible and to install the 100 kg/h glass melter in HWVP at startup is made in this report. Following are required Fiscal Year (FY) 1989 tasks to support this recommendation:

a. Define required modifications to maximize the B Plant dissolution/transuranic extraction (TRUEX) capacity.

b. Adjust HWVP baseline plans to reflect vitrification with 100 kg/h melter.

2. Can an alternate facility to B Plant be used for the TRUEX process?

The costs for treatment of DST wastes using alternate facilities (expanded HWVP, new stand-alone, or PUREX) are approximately the same or slightly higher than for the B Plant facility. The use of an expanded HWVP is approximately the same cost as B Plant. However, this requires a committment by March 1989 (i.e., prior to commencing definitive design). The expanded HWVP would require an increase in the HWVP project cost and delay of the vitrification schedule by at least 6 mo. The cost for use of the PUREX facility is approximately $50 million more than for the B Plant facility. The availability of the PUREX facility is contingent upon changing the N Reactor cold standby status to shutdown status. The use of a new stand-alone facility increases total program costs by $100 million over B Plant costs and delays completion of the vitrification program by 2 yr since the new stand-alone facility could not be on-line before FY 2001. Thus the decision to not utilize an alternate TRUEX facility is justified by the absence of any cost savings and inadequate technical justification for a major programmatic change.

Technology development required: None

3. Is additional removal of radionuclides in grout feed to 10 CFR 61 Class A levels desirable?

Based on input from outside agencies [Nuclear Regulatory Commission (NRC), Environmental Protection Agency (EPA), and Washington State] and future comprehensive performance assessments, it may be desirable to reduce the concentrations of radionuclides in low-level waste (LLW) grouts to significantly lower levels than those defined by the current grout criteria. Radionuclide concentrations currently meet Class C levels (10 CFR 61); however, preparation of LLW grouts with radionuclide contents comparable to Class A levels or to the same levels as Savannah River Plant (SRP) grouts may be deemed desirable. The primary radionuclides of concern and considered as candidates for additional radionuclide removal are ^{90}Sr, ^{137}Cs, and the transuranic (TRU) components. Major pretreatment process changes will be required to reduce radionuclide contents of waste supernatants by the approximate factors of 10 to 1,000 needed. The "yes" route to this decision is denoted in the figure as a dashed line since elucidation of further decision points and the resulting cases and associated costs need to be determined. However, pretreatment processes that utilize sludge washing and/or sludge dissolution and the TRUEX process are envisioned.

If the TRUEX process is utilized, the radionuclide decontamination required would be greater than if only sludge washing is used since acid dissolution of the sludge releases additional ^{90}Sr and ^{137}Cs into the acid TRUEX feed. The TRUEX process does not remove ^{137}Cs and ^{90}Sr values. If the sludge wastes are treated using only sludge washing, ^{137}Cs and ^{90}Sr could be removed from alkaline supernatants in a DST using technology that is presently being developed at SRP. The ^{137}Cs is precipitated using sodium tetraphenylborate, and ^{90}Sr and TRU are precipitated by addition of sodium titanate. If the TRUEX process is used, however, removal ^{137}Cs and ^{90}Sr in acidic solution would be required. Technology for removal of ^{137}Cs and ^{90}Sr in acidic solutions to the required

levels has not been demonstrated although several candidate methods appear feasible. The ability to develop this technology to support a FY 1999 HWVP startup is presently unsure. Studies of alternate pretreatment processes to reduce the radionuclide content in both alkaline and acidic supernatant solutions is required on an immediate basis to ascertain the feasibility of producing a Class A grout. The following development activities are required in anticipation of resolving the issue which is expected by the end of FY 1989.

a. Perform laboratory and hot-cell tests to evaluate SRP ^{137}Cs and ^{90}Sr removal processes on DST alkaline waste supernatants.

b. Evaluate ^{137}Cs ion exchange flowsheet and equipment sizing to equal SRP ^{137}Cs removal efficiency.

c. Evaluate methods for reducing ^{90}Sr and ^{137}Cs levels in acidic TRUEX process solutions.

4. Can neutralized current acid waste (NCAW) be washed in a DST?

Washing NCAW sludge in a double-shell tank or AR Vault may be a viable option as the result of the decision to place the N Reactor in cold standby. Originally the pretreatment system had to provide the capability of processing current discharged fuel waste. Irradiation of N Reactor fuel was complete in 1986 and all Fast Flux Test Facility (FFTF) mixed-oxide fuel will complete irradiation in 1991. Pretreatment processing of NCAW is all on aged waste and previous heat transfer limitations are less restrictive to the extent that a small 5,000-gal-batch size may no longer be required. With a "yes" decision, in-tank washing of NCAW eliminates 4.5 yr of B Plant processing time and allows full support of a 100 kg/h HWVP melter. This alternate NCAW sludge-washing system potentially results in an additional $250 million cost savings over the $250 million cost savings from TRUEX

capacity increase only, (Case G vs Case C). Input data required for the decision includes heat transfer analysis, safety analysis and impact on tank farm operations.

The following development activities are required to support this decision by the latter part of FY 1990.

a. Prepare technical analysis of washing NCAW in a DST.

b. Develop NCAW in-tank wash technology as required.

c. Prepare B Plant plan for NCAW in-tank washing, accelerated TRUEX process implementation, and preparation of Waste Form Qualification (WFQ) samples.

5. Is TRUEX applicable to NCAW?

Application of the TRUEX process to NCAW is an alternate to washing NCAW in a DST, and also provides a potential $300 million cost savings over the enhanced baseline case by eliminating 4.5 yr from the B Plant and HWVP operating schedule (compare Case D vs Case C). The decision requires TRUEX processing of NCAW in lieu of Plutonium Finishing Plant (PFP) sludge. The TRUEX processing of NCAW requires 95 to 99% strontium removal to meet grout Class C LLW limits. Extensive development work is required in the next 2 yr to assure flowsheet performance (strontium removal) and commit to a 1994 line item that supports the 1999 HWVP startup.

Following are required development activities to support this decision by the end of FY 1990. The extent of the work requires that the development activities be performed in FY 1989 and FY 1990.

a. Obtain samples and determine dissolution behavior of the waste sludges in H_2O, HNO_3, and HNO_3-HF.

b. Determine TRUEX solvent distribution coefficients for the TRU elements in synthetic wastes and in dissolver samples from (a).

c. Perform hot-cell tests on strontium removal with antimonic acid ($Sb_2O_3 \cdot 4H_2O$) in dissolver solutions, and rare-earth sulfate precipitation in TRUEX raffinate.

6. Is the TRUEX process applicable to PFP, complexant concentrate (CC), and neutralized cladding removal waste (NCRW)?

a. The application of the TRUEX process to PFP, CC, and NCRW with in-tank washing of NCAW (Case G) saves $500 million over the baseline Case A by eliminating 4.5 yr of B Plant processing time and allowing continuous operation of the 100 kg/h melter. Assuming favorable decisions to the preceding issues, this is the preferred process route for pretreatment of Hanford DST waste. This route is indicated by the heavy line in the logic diagram. The required development work is the same as for Task (a) and (b) for Issue 5. The TRUEX process is implemented in 1997 (1994 line item). The decision on the application of the TRUEX process to CC, PFP and NCRW should be made by FY 1991.

b. Application of the TRUEX process to PFP, CC, and NCRW with NCAW sludge washing in B Plant is the "enhanced" baseline case (Case C) with a total cost of approximately $3.15 billion. For this case some discontinuity of HWVP operations (approximately 2 yr) results from inability of B Plant to provide continuous feed near the latter part of the pretreatment campaign. Additional costs are incurred by the lengthy campaign (4.5 yr) required to wash NCAW sludge in B Plant and forces a mid-FY-2000 implementation of the TRUEX process (1997 line item). The decision on the application of the TRUEX process to CC, PFP, and NCRW should be made by FY 1994.

If the TRUEX process cannot be applied to PFP, CC, and NCRW wastes, sludge washing of PFP and NCRW would be required in a DST, and NCAW would be washed in B Plant. Without the TRUEX process, preparation of LLW grout from CC would require removal of TRU components by destroying the complexants. The estimated cost for this route (Case B) is approximately $3.8 billion. The required development work is the same as Tasks (a) and (b), Issue 5.

7. Can complexant destruction (CD) be done in a DST?

If the TRUEX process cannot be applied to DST waste the TRU content in CC must be reduced to <100 nCi/g using a CD process. Performing CD in a DST rather than B Plant would enable all waste pretreatment operations to be performed in DSTs with the exception of removing cesium from NCAW supernatant. Operation of B Plant for just cesium removal could be relatively expensive. An addition to the HWVP to enable removal of cesium from NCAW supernatant (and other waste supernatants if necessary) could be provided for approximately $50 million. This option (Case F), which would utilize DST facilities and HWVP for waste pretreatment, would have the same total cost as the baseline Case A option of $3.4 billion. In-tank destruction of complexants must be evaluated and demonstrated to support this decision. If in-tank CD cannot be performed, B Plant would be used for CD and also likely for cesium removal (Case E) at a cost of approximately $3.7 billion.

The following development activities are required to support this decision by FY 1993.

a. Perform development and engineering work necessary to define destruction of organic complexants in-situ in a DST.

b. Evaluate capability for add-on of ^{137}Cs decontamination process to HWVP to incorporate capabilities for removing ^{137}Cs from stored NCAW supernatant.

8. Is the B Plant facility acceptable for DST waste pretreatment?

Evolving changes to applicable orders and regulations create potential impacts on requirements for upgrading and operating processing facilities. Ongoing upgrades at B Plant will provide compliance with existing regulations for the NCAW pretreatment mission. In particular, new standards and regulations for management and control of hazardous wastes and liquid effluents will be implemented. The upgrades presently being implemented in B Plant will provide conformance with existing state and federal laws. The need for B Plant to comply with emerging requirements (e.g., DOE Order 6430.1A) is uncertain. Imposing DOE Order 6430.1A compliance as a B Plant upgrade will delay completion of the vitrification program and may not be cost effective. Operation of a pretreatment mission for single-shell tank (SST) waste without DOE Order 6430.1A compliance is deemed to be unlikely. Thus, construction of a new stand-alone facility would likely be required for processing large volumes of SST wastes. A "no" decision on utilizing B Plant for DST wastes could require DST waste pretreatment to be limited to in-tank sludge washing (Case F) to support a FY 1999 startup of HWVP. If the decision is made after FY 1993 that B Plant is not an acceptable facility for waste pretreatment, the program costs for Case F will be greater than the $3.4 billion indicated.

The tasks listed for Issue 7 are required to maintain a backup in-tank sludge-washing option to utilization of B Plant for DST pretreatment operations.

The following additional task is also required to support this decision:

a. Continue evaluation of B Plant compliance to emerging regulatory requirements.

APPENDIX E

FACILITY DESCRIPTIONS AND COST ESTIMATIONS-- EXPANDED HANFORD WASTE VITRIFICATION PLANT AND NEW STAND-ALONE FACILITY

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APPENDIX E

FACILITY DESCRIPTIONS AND COST ESTIMATIONS-- EXPANDED HANFORD WASTE VITRIFICATION PLANT AND NEW STAND-ALONE FACILITY

This appendix describes the alternatives for: (1) Pretreatment of waste in an expanded Hanford Waste Vitrification Plant (HWVP), (2) Pretreatment of waste in a new stand-alone facility.

Facility descriptions and proposed layouts are provided. Preliminary facility cost estimates [Fiscal Year (FY) 1988 dollars] were performed by Kaiser Engineering Hanford Company and are also provided in this appendix.

E.1.0 PRETREATMENT IN HANFORD WASTE VITRIFICATION PLANT

The pretreatment process is depicted as a flow diagram in Figure E-1. Locating this equipment in a canyon facility with a nominal 20 ft cell width requires about 375 lineal feet of process cell. An addition of this magnitude affects structural features; heating, ventilation and air conditioning (HVAC), utilities, etc. The design impacts of this expansion are discussed below.

E.1.1 HANFORD WASTE VITRIFICATION PLANT CONFIGURATION

The baseline design for HWVP is defined in the reference Conceptual Design Report (WHC-EP-004), dated July 1987. A plan and section of the vitrification building are shown in Figures E-2 and E-3. A manipulator maintenance building, located on the north end of the vitrification

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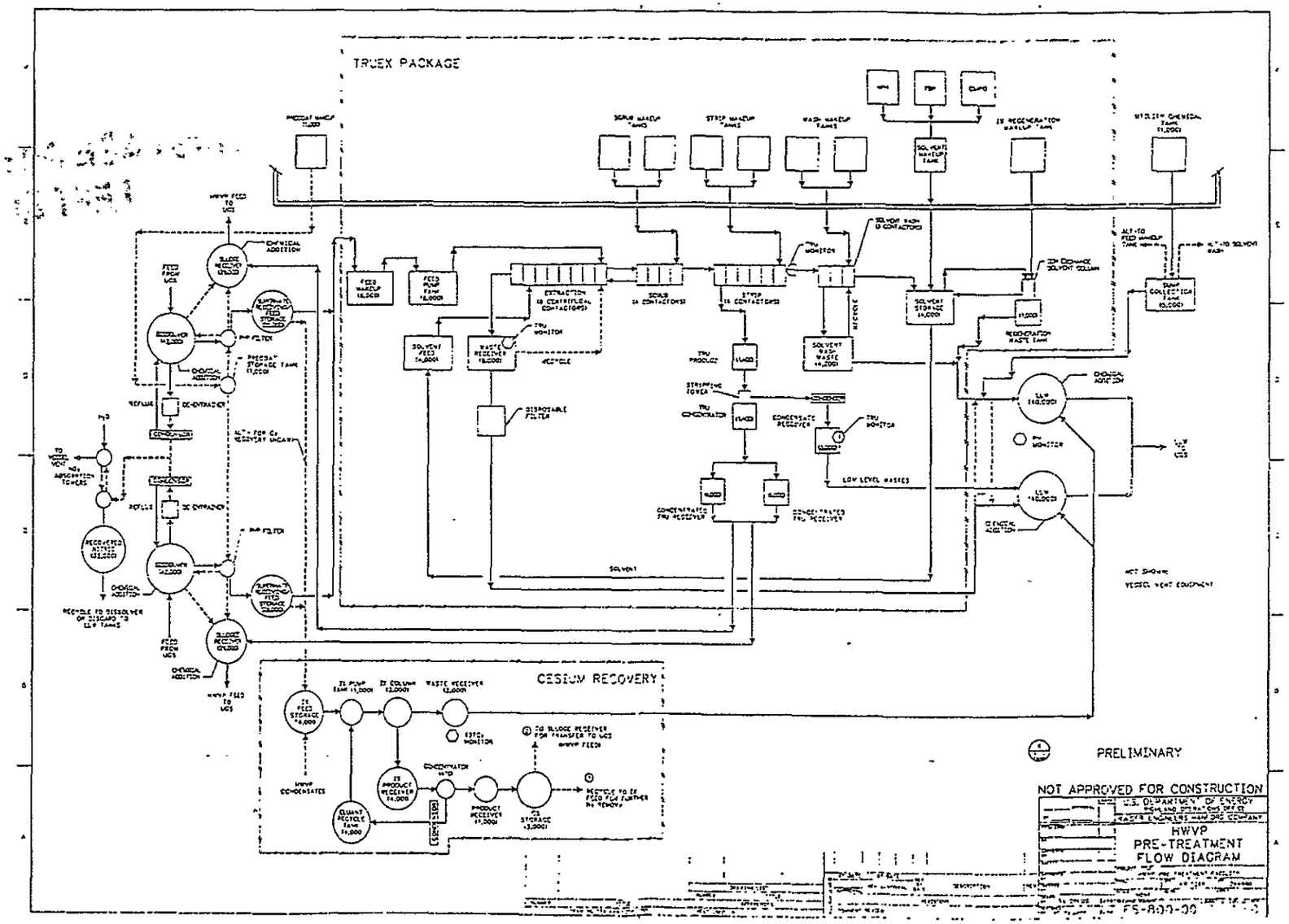

Figure E-1. Hanford Waste Vitrification Plant Pretreatment Flow Diagram.

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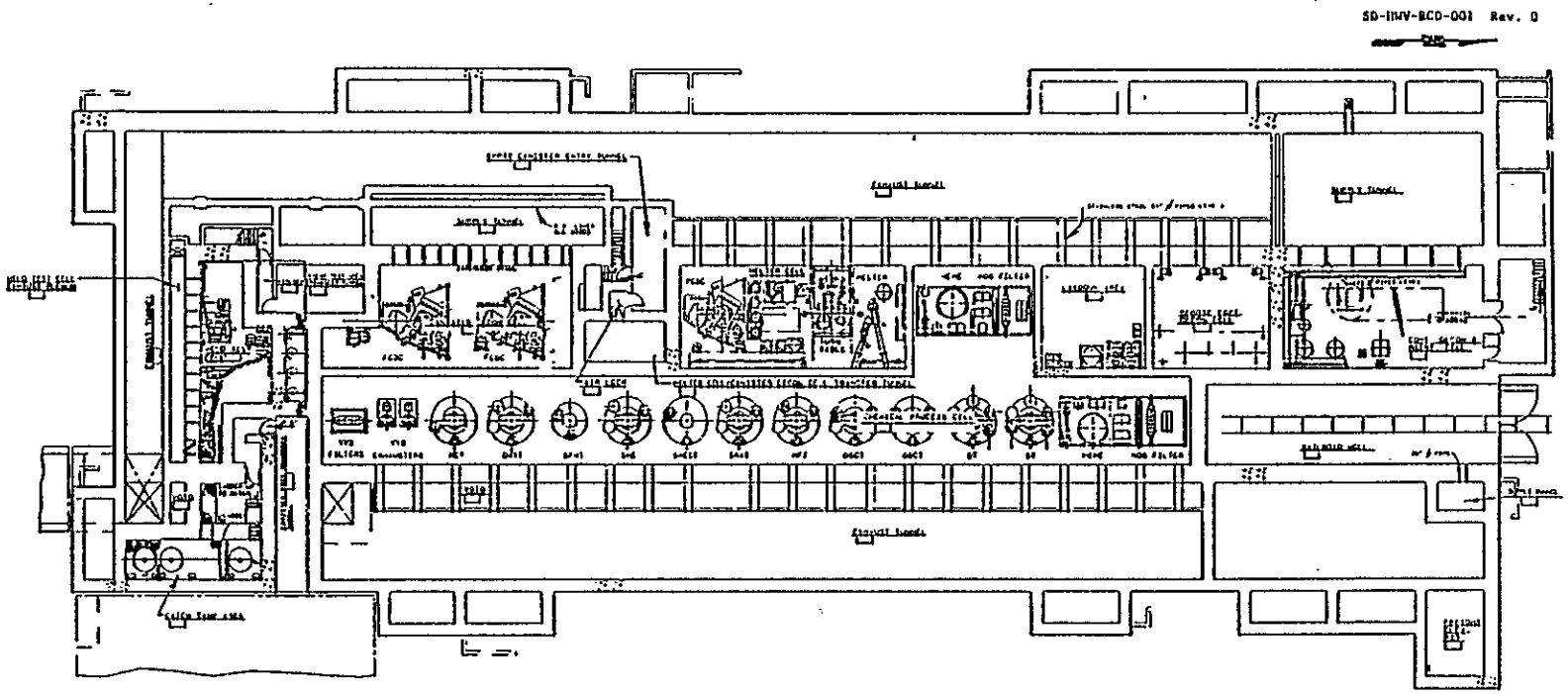

Figure E-2. Vitrification Building Tunnel Plan Process Equipment Arrangement.

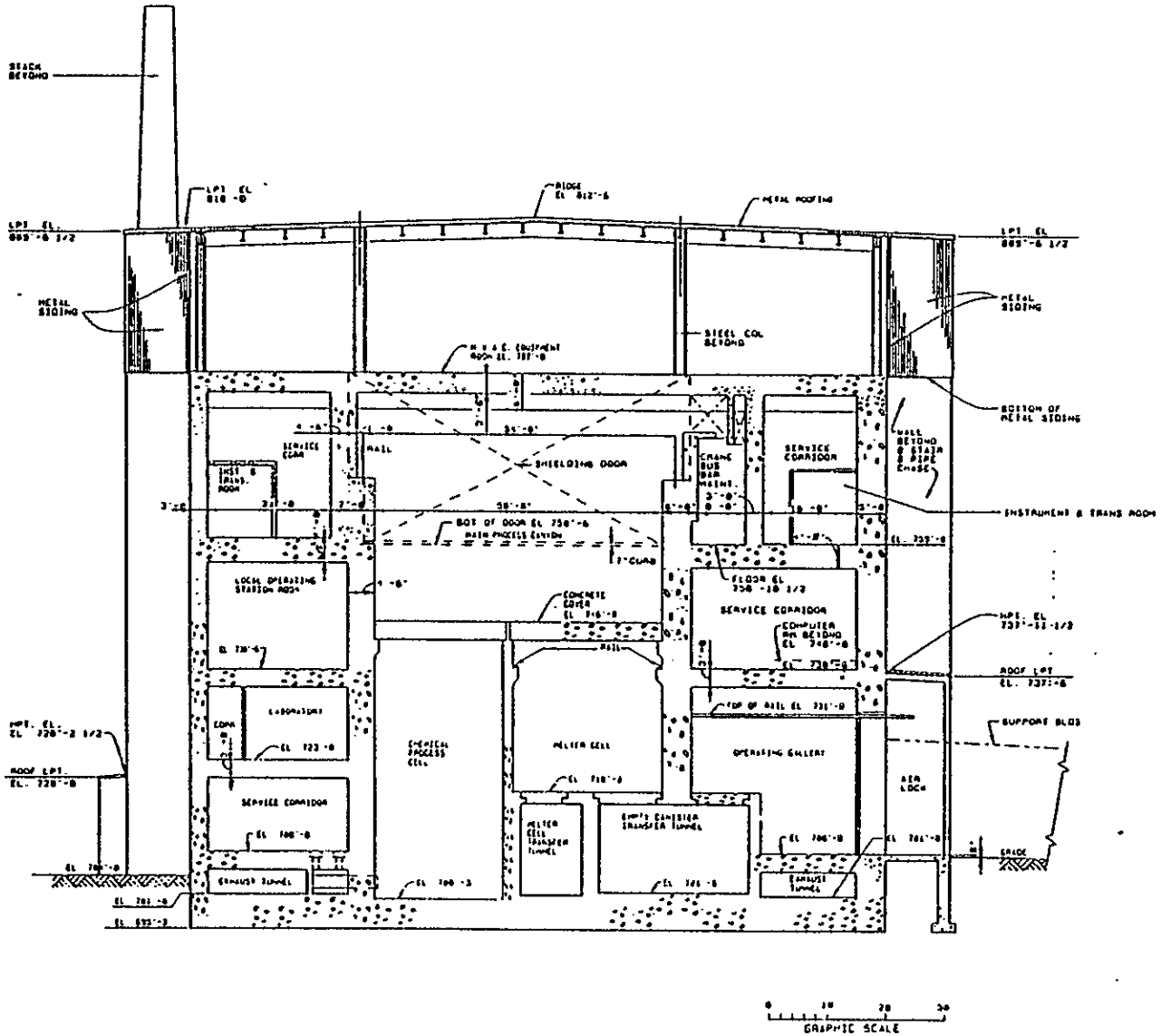

Figure E-3. Vitrification Building Section.

building, can be relocated such that the vitrification building can be extended to the north without interference. Existing cell features and equipment arrangements are unchanged for the original HWVP mission. The canyon and operating galleries are extended northward about 200 ft through the use of two parallel cells as shown in Figures E-4 and E-5. Extra space for equipment laydown and repair is provided such that the existing laydown area and remote equipment decon cell (REDC) can be expanded to support the pretreatment equipment.

E.1.2 HEATING, VENTILATION, AND AIR CONDITIONING IMPACTS

The cell ventilation requirement is typically four-to-five air changes per hour for a PUREX-type canyon facility. Five air changes per hour was assumed based on previous Hanford experience.

The additional cell length imposes an extra 30,000 ft^3/min of Zone 1 air on the sand filter and the fan house. The existing system is 107,000 ft^3/min. Expansion of the existing system was selected rather than adding a second system because the increase is relatively small (27%).

The two major items affected by the 27% air flow volume increase are listed in Table E-1 with the current HWVP estimated costs.

Table E-1. Impact of Air-Flow Volume Increase--Cost Estimates (Millions of Dollars).

Work package	Description	Direct cost	Hanford Waste Vitrification Plant estimate[a]
C12	Sand filter and air tunnel	$7.5	$12.8
C13	Fan house and stack	$8.4	$14.6

[a] Includes escalation and contingency.

The HVAC Zone 2 and Zone 3 systems would also see a corresponding increase in load of about 30%.

E.1.3 PROCESS STEAM AND COOLING WATER

The total evaporation in the pretreatment equipment will not exceed 20 gal/min in the dissolvers and transuranic (TRU) concentrator. This equates to 10,000 lb/h (10 M Btu/h) of process steam at maximum process use. An equivalent process cooling water load is assumed to serve the condensers.

The existing HWVP systems are shown in Table E-2.

Table E-2. Impact of Pretreatment at Hanford Waste Vitrification Plant--Percent of Load Capacity Increase to Present Systems.

Description	Present capacity	Added load	Percent increase
Process steam (closed loop)	25,000 lb/h	10,000 lb/h	40%
Process cooling water (closed loop)	20.8 M Btu/h	10 M Btu/h	50%

These changes will impact present sizing for the closed-loop heat exchangers and distribution piping. Closed-loop room sizes will have minor increases, if any.

E.1.4 ELECTRICAL SYSTEMS

Fan motors for the Zone 1 HVAC would be increased from 600 horsepower to 900 horsepower to accommodate the 27% increase. Adequate electrical

power exists for the changes to fans for Zones 1, 2, and 3. Process equipment motors are a minor impact. The overall electrical system cost increase should be 3 to 5% or about 1.5 million.

E.1.5 PROCESS SAMPLING

The equipment items shown on the pretreatment flow diagram (Figure E-1), will require about 40 sample points. The sample stations will be housed in concrete shielded caves equipped with viewing windows and manipulators. Seven samplers can be located in front of one window/ manipulator station. Two caves will serve the pretreatment equipment. Eight shielded windows and eight sets of Model F manipulators will be required. Both caves will be equipped with an overhead hoist serving the cave internals and a transfer drawer for passing samples out of the cave. Additional laboratory space will be provided in operating gallery mezzanines located on both sides of the canyon.

E.1.6 CANYON CRANE

The canyon cells can be extended in parallel such that the canyon crane coverage will include the pretreatment additions. The existing crane will adequately serve both the pretreatment and HWVP cell equipment with an extension for the rails and power/control supply.

The canyon crane has no routine operational function and is used solely for jumper and equipment changeout. One crane can be expected to cover the pretreatment equipment in addition to the original HWVP maintenance functions.

E.1.7 OTHER HANFORD WASTE VITRIFICATION PLANT IMPACTS

The vitrification building extension entails utility tie-ins for sanitary water and raw water. The office space impact is described in Section E.2.8.

E.1.8 COST AND SCHEDULE IMPACTS FOR HANFORD WASTE VITRIFICATION PLANT EXPANSION

HWVP project costs are shown in Table E-3 by years.

Table E-3. Hanford Waste Vitrification Plant Expansion Cost Projections--Fiscal Year 1988 through 1993 (Millions of Dollars).

Fiscal year	Fluor engineering	Westinghouse Hanford support	Kaiser Engineering Hanford management support
		Preliminary design	
1988	4.5	2.8	0.2
1989	16.9	4.7	0.9
		Detailed design	
1990	18.0	7.2	1.0
1991	30.5	10.3	3.6
1992	36.8	11.0	9.5
1993	20.1	9.5	6.1

The preliminary phase of design consists largely of project engineering baseline development, including process flow diagrams and facility configuration control drawings. If a change request was implemented prior to FY 1990, the cost of abandoned design would not exceed 25% of the design cost to that date. The change request could be implemented for under $5 million and the preliminary design for the vitrification portion of the dual purpose facility could be completed within six months of the original

schedule. Start of construction would also be delayed unless work-around procedures could be developed. The architect/engineer (A/E) could plan the design work to minimize impacts, with guidance as to when the decision would be implemented. A parallel study conducted by Fluor Engineering in FY 1989 could serve to assess the cost and schedule impacts of the new work scope and serve as the basis for an implementation change. The cost of this kind of assessment would be $75 to $200 K.

The primary conclusion is that funding a change of this magnitude cannot be made efficiently after the start of detailed design in FY 1990. In reality a preliminary decision to fund a Fluor assessment of the change needs to be made in FY 1988 with a final commitment in FY 1989.

Assuming a timely decision as discussed above, the cost impacts would be as follows:

1.	Rework preliminary HWVP design to implement change	5 M
2.	Added Westinghouse Hanford support to cover new scope (5 to staff)	2 M
3.	Total project cost with escalation and contingency	215 M
4.	Added escalation assuming 6 mo delay	<20 M
5.	Westinghouse Hanford process development	25 M
6.	Westinghouse Hanford Preliminary Safety Analysis Report/ Environmental Impact Statement changes	1 M
		268 M

E.2.0 PRETREATMENT IN A NEW STAND-ALONE FACILITY

The new pretreatment facility is a remote canyon facility with parallel cells spanned by a single crane. The cell layout contains the equipment shown on the Pretreatment Flow Diagram (Figure E-1).

E.2.1 GENERAL LAYOUT

The cells, galleries and rooms are conservatively sized and could probably be reduced with additional detail from a later stage of design. The cells are 20 ft wide, and the galleries are 25 ft wide. As shown on the plans and sections, space is reserved for all the necessary supporting features of a stand-alone facility (see Figure E-6).

E.2.2 SITE LOCATION

The new pretreatment facility will be located in the vicinity of HWVP and B Plant. Space exists east of the HWVP site which is near a rail spur.

E.2.3 HEATING, VENTILATION AND AIR CONDITIONING

The Zone 1 ventilation requirement is typically four-to-five cell air changes per hour for a PUREX-type canyon facility. This amounts to a flow rate of about 25,000 ft^3/min which approximates the Process Facility Modifications Project (PFM) system. Upflow remote high-efficiency particulate air (HEPA) filters similar to the PFM design were assumed rather than a sand filter. The remote HEPA filter room has a size and layout comparable to that used in PFM to accomplish the first two stages of filtration.

An additional room is designated for the third stage of Zone 1 filtration (43 ft x 63 ft). Exhaust HVAC areas for Zones 2 and 3 and supply for all zones will be housed in two rooms each 61 ft x 60 ft.

E.2.4 MAINTENANCE AND REPAIR

Ingress/egress for new or failed cell equipment is based on rail or truck receipt and an interface with the canyon crane through coverblocks. The rail receipt area is sized to handle the new multipurpose transfer box

mounted on a flatcar. The ingress/egress routes from the rail and truck area to the cell will support transporting equipment up to 30 ft high in a vertical orientation. With the exception of one concentrator, which is 25 ft high, the remaining cell equipment is about 15 ft high.

Failed equipment or jumpers can be remotely decontaminated, cut up or repaired in the failed equipment cut-up area. This cell is equipped with viewing windows and manipulators and is accessible for manned entry to support remote decontamination and contact repair in a 26 ft x 33 ft cell. A Zone 2 hot shop (118 ft x 16 ft) is also provided in the same vicinity. The lower floor gallery will house cold maintenance and storage functions in a Zone 4 area.

Crane maintenance is accomplished at one end of the canyon. A parapet wall and isolation door are used to isolate the crane maintenance area from the canyon for decontamination and repair. Liners and drains will be used to facilitate decontamination, and thereby, keep the crane maintenance area within ALARA guidelines for personnel exposure.

E.2.5 ANALYTICAL SUPPORT

Three sample caves are shown on the -15 ft level (second floor). These caves are equipped with remote viewing windows, manipulators, a small internal hoist and a transfer drawer to remove samples. Room exists in the sample gallery for some analytical support equipment and storage. In addition, a laboratory room 61 ft x 60 ft is located just off the sample gallery on the second floor (Figure E-6).

E.2.6 CHEMICAL MAKEUP

The entire fourth floor gallery (25 ft x 90 ft) is reserved for aqueous makeup (AMU) and dry chemical storage. A ceiling height of 15 ft was used to allow removal of agitators from the makeup tanks.

An exterior bulk chemical storage area is also required for AMU supplies of nitric acid, sodium hydroxide and hydrogen peroxide. The tanks listed below would be housed in a lined concrete pit capable of containing the entire contents of a single tank in the event of a leak.

HNO_3	2 at 20,000 gal each
NAOH	2 at 15,000 gal each
H_2O_2	6 at 20,000 gal each

E.2.7 PROCESS PIPING

Sparing patterns in the hot pipe trench will be provided to maximize the flexibility for future process needs. The hot pipe trench is located between the two parallel cells. The piping will be above the top of the vessels to preclude misroutings from overflows, etc. The closed loop gallery is located immediately below the hot pipe trench. It will house piping valves and controls to connect the cell with the primary and secondary heat exchangers for process heating (steam) and cooling (water). Manned entry to the closed loop room can be made through air locks on either end of the corridor. The primary loop routings in the closed loop corridor and the heat exchange room are not occupied during plant operations to preclude the threat of personal exposure from a failed coil.

E.2.8 PERSONNEL SUPPORT FEATURES

Six offices, a lunchroom and change rooms are attached to one end of the hardened structure. The Zone 4 control room is located within the hardened portion of the building. Special security features are not required for this facility. Access control is maintained through the use of locked doors.

Additional office space for 200 people is included to support the staff related to the pretreatment facilities. The construction envisioned is

similar to 2751E, 2752E and 2753E office buildings constructed via projects B-509, -457, and -485. The cost in 1986 dollars for a 30,000 ft^2 facility is about $1.5 million (~$55/ft^2).

E.2.9 TRAFFIC PATTERNS

Personnel traffic throughout the building is accomplished by the following means:

- Access to the grade floor instrument/service gallery is mainly through (a) the corridor adjacent to stairwell 4; (b) the control room, which is not a major traffic path; or (c) the elevator on the opposite end of the building. Stairwell 2 is used as an emergency escape route.

- Access to the -15 ft, 0 in. level service/sample gallery is mainly through the men's or women's change room and stairwells 3 and 4. Stairwells 1, 2, and 5 are used as emergency escape routes.

- Access to the -37 ft, 0 in. level storage/maintenance gallery (Reference ES-800-02) is mainly through stairwell 5 from grade level. The entry from stairwell 5 to the -15 ft level sample gallery is for emergency use only. The sample gallery will require protective clothing, whereas stairwell 5 does not. Access is also through the elevator and stairwell 1.

- Access to the hot shop area side of the cells on the -37 ft, 0 in. level is mainly through the men's or women's change room and stairwells 3 and 4. The elevator area is another entrance into the building through the storage/maintenance area then through an airlock. This access is a controlled access. Stairwell 2 can be used as an escape route.

- Access to crane maintenance is limited to a traffic route through the men's or women's change room and stairwells 3 and 4.

E.3.0 COST ESTIMATING

Cost estimates were prepared by Kaiser Engineering Hanford Company and reviewed by Westinghouse Hanford. The technique used is a parametric computer model called the Freiman Analysis of Systems Technique (FAST). This method of estimating is used by the U.S. Department of Energy (DOE) in the assessment of projects being considered for validation.

The model is calibrated by comparison to similar facilities. The following projects were used as a basis for comparison:

- Process Facility Modifications Project
- New Waste Calciner Facility (NWCF)
- Hanford Waste Vitrification Plant
- Hanford Waste Vitrification Plant Vitrification Wing.

The FAST factors and costs are summarized for the above facilities and the two proposed alternatives in Table E-4. The size of the stand-alone facility is similar to PFM (see Table E-5) although somewhat less complex.

Table E-4. Cost Factor Summaries--Facility Option Comparisons (FASTc Cost Factors).

FASTc factors	HWVP	Vitrification Building	Expanded HWVP	Stand-alone pretreatment	PFM	INEL[a] NWCF
Platform	1.35	1.55	1.45	1.45	1.50	1.43
Structure	14.560 ($87.5 M)	13.643 ($58.7 M)	13.643 ($22.0)	19.623 ($37.0)	19.623 ($46.2)	17.235 ($26.4)
HVAC	3.270 ($21.5 M)	2.951 ($11.7 M)	4.67 ($7.0 M)	4.67 ($9.1 M)	7.473 ($16.4 M)	3.236 ($4.8 M)
Electrical/ mechanical	44.756 ($233.2 M)	47.874 ($140.9 M)	28.957 ($36.0 M)	28.957 ($47.5 M)	33.389 ($62.1 M)	28.957 ($34.8 M)
Utility cost	.147 ($3.6 M)	---	10.741 ($3.6 M)	10.741 ($3.6 M)	99.426 ($9.9 M)	64.015 ($3.7 M)
Miscellaneous	($25.4 M)	---	$0.123 M	$2.6 M	$5.1 M	$6.5 M
Direct cost	$371.2 M	$211.3 M	$68.8 M	$99.8 M	$139.7 M	$76.2 M
BLDMX	61.457	46.525	50.133	56.36	57.18	42.686
Unit cost/ft^2 (ft^2 of area)	$833.0 (415,000)	$1,132.0 (185,000)	$894.0 (79,000)	$951.0 (100,000)	$1,169.0 (115,000)	$801.0 (87,000)
Engineering cost	$114.0 M (30%)	---	$20.6 M (30%)	$29.8 M (30%)	$67.4 M (50%)	$12.2 M
Project management	$61.1 M (16%)	---	$11.0 M (16%)	$20.0 M (20%)	$10.6 M (4%)	$1.6 M
Construction management	$21.8 M	---	$6.2 M	$9.0 M	$11.3	---
Subtotal	$568.1 M	211.3 M	$106.6 M	$158.6 M	$299.0 M	$90.0 M
Escalation	$190.4 M	---	$52.4 M	$77.6	$15.2 M	---
Contingency	$161.4 M	---	$55.8 M	$83.8 M	$10.8 M	---
Total project cost	$920.0 M	$211.3 M	$215.0 M	$320.0 M	$255.0 M	$90.0 M
Without escalation	---	---	$162.0 M	$242.0 M	---	---

[a] Idaho National Engineering Laboratory (INEL).

Table E-5. Process Facility Maintenance Project and Stand-Alone Pretreatment Facility Comparisons by Size.

Lineal feet of cell (ft)	Foot print at grade (ft^2)	Average height (ft)	Building volume (ft^3)	Total concrete volume (yd^3)	Total square feet (ft^2)
Process facility maintenance project					
325	80,000	75	6.0 M	31,000	115,000
Stand-alone pretreatment					
375	60,000	90	5.4 M	33,000	100,000

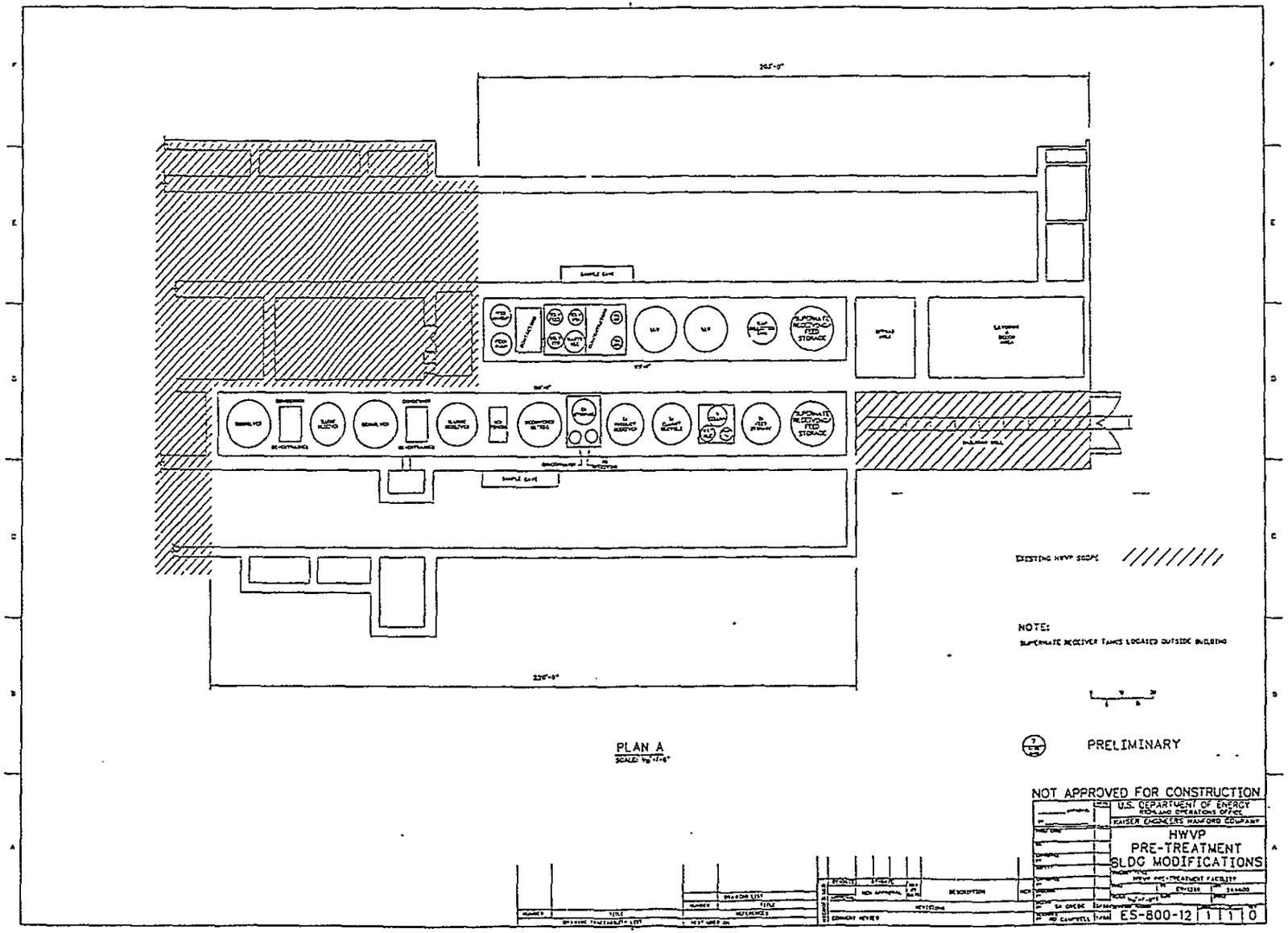

Figure E-4. Hanford Waste Vitrification Pretreatment Building Modification.

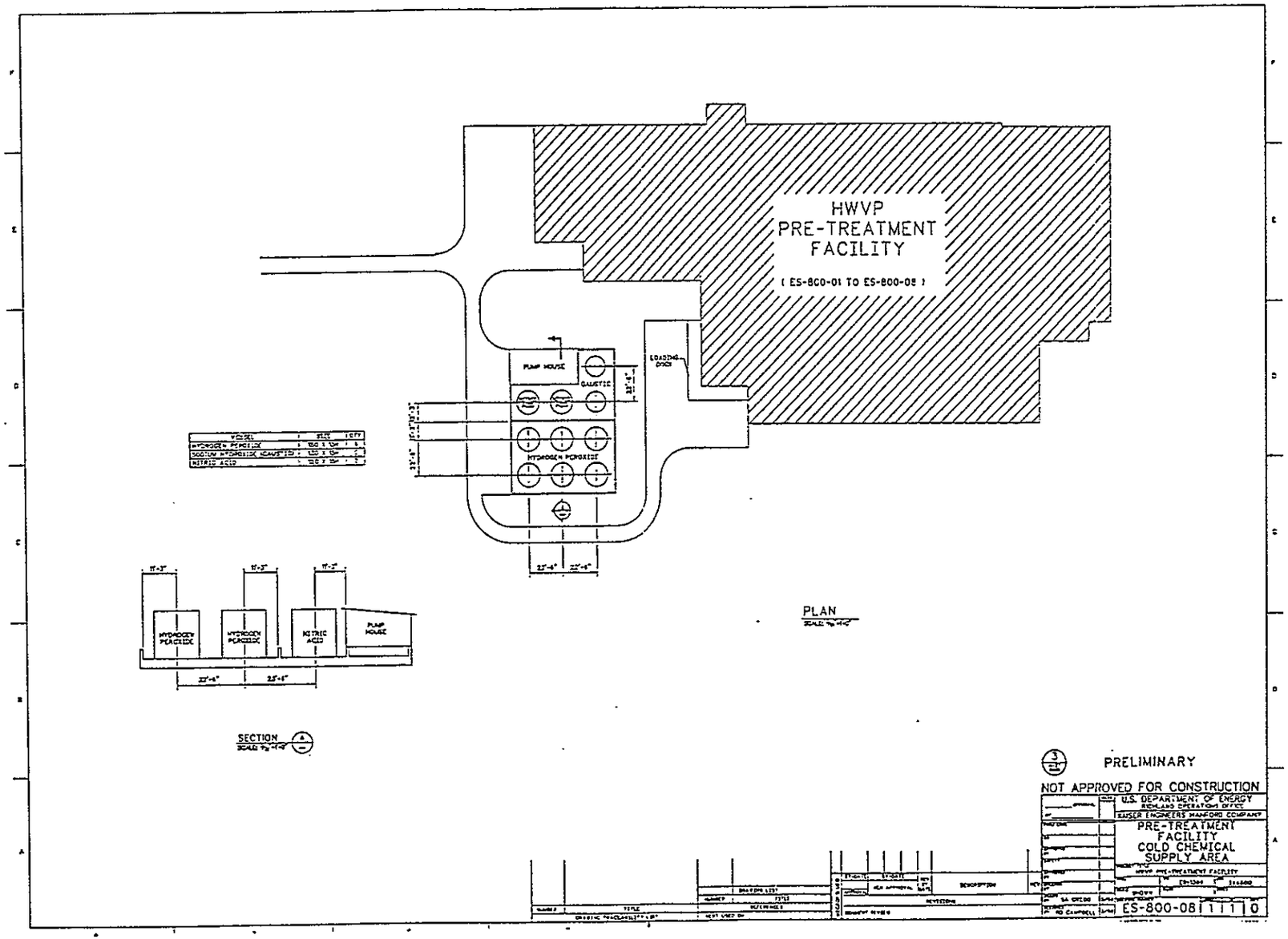

Figure E-5. Pretreatment Facility Cold Chemical Supply Area.

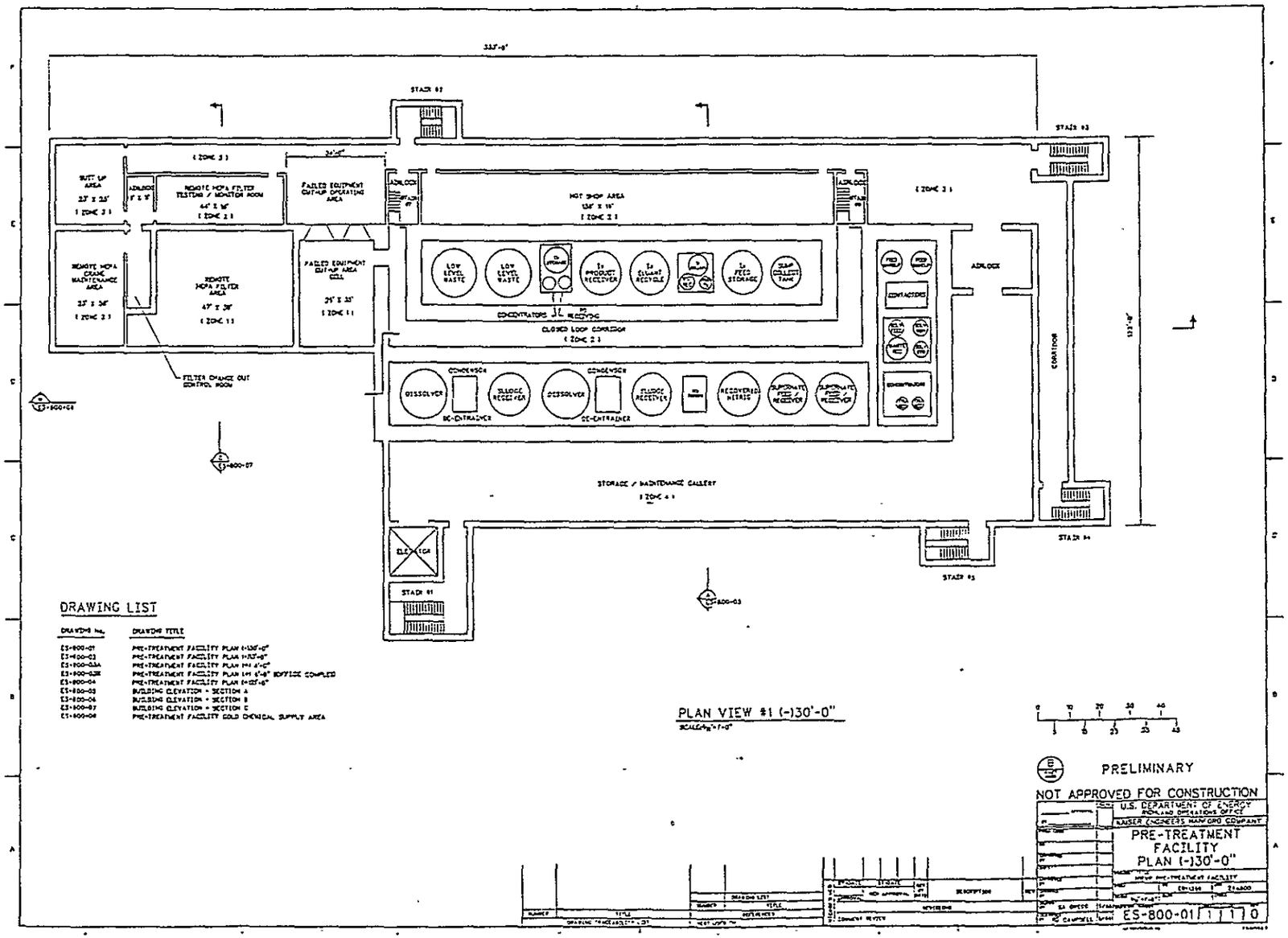

Figure E-6. Pretreatment Facility Plan (-)30'-0". (Sheet 1 of 8)

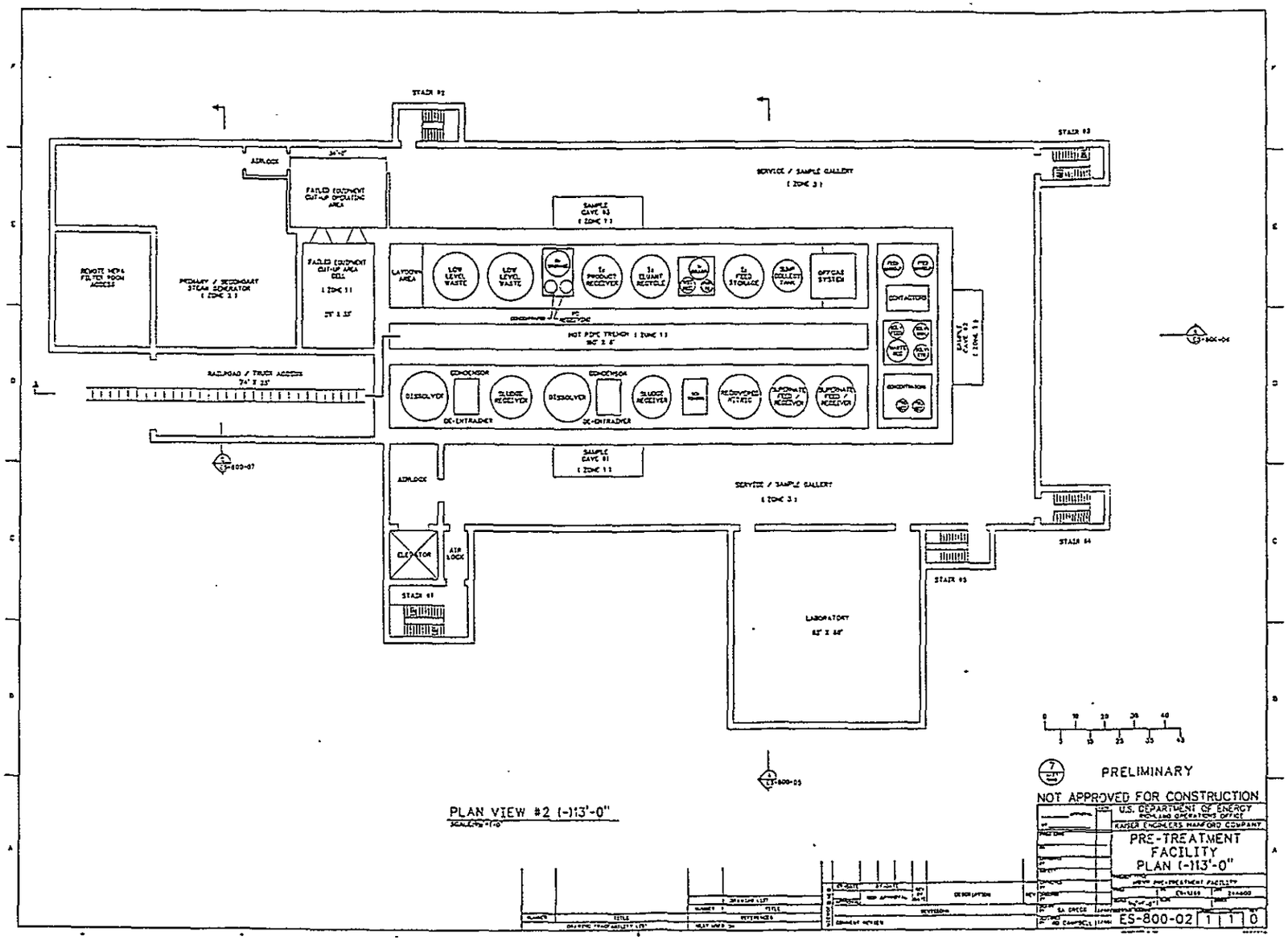

Figure E-6. Pretreatment Facility Plan (-)13'-0". (Sheet 2 of 8)

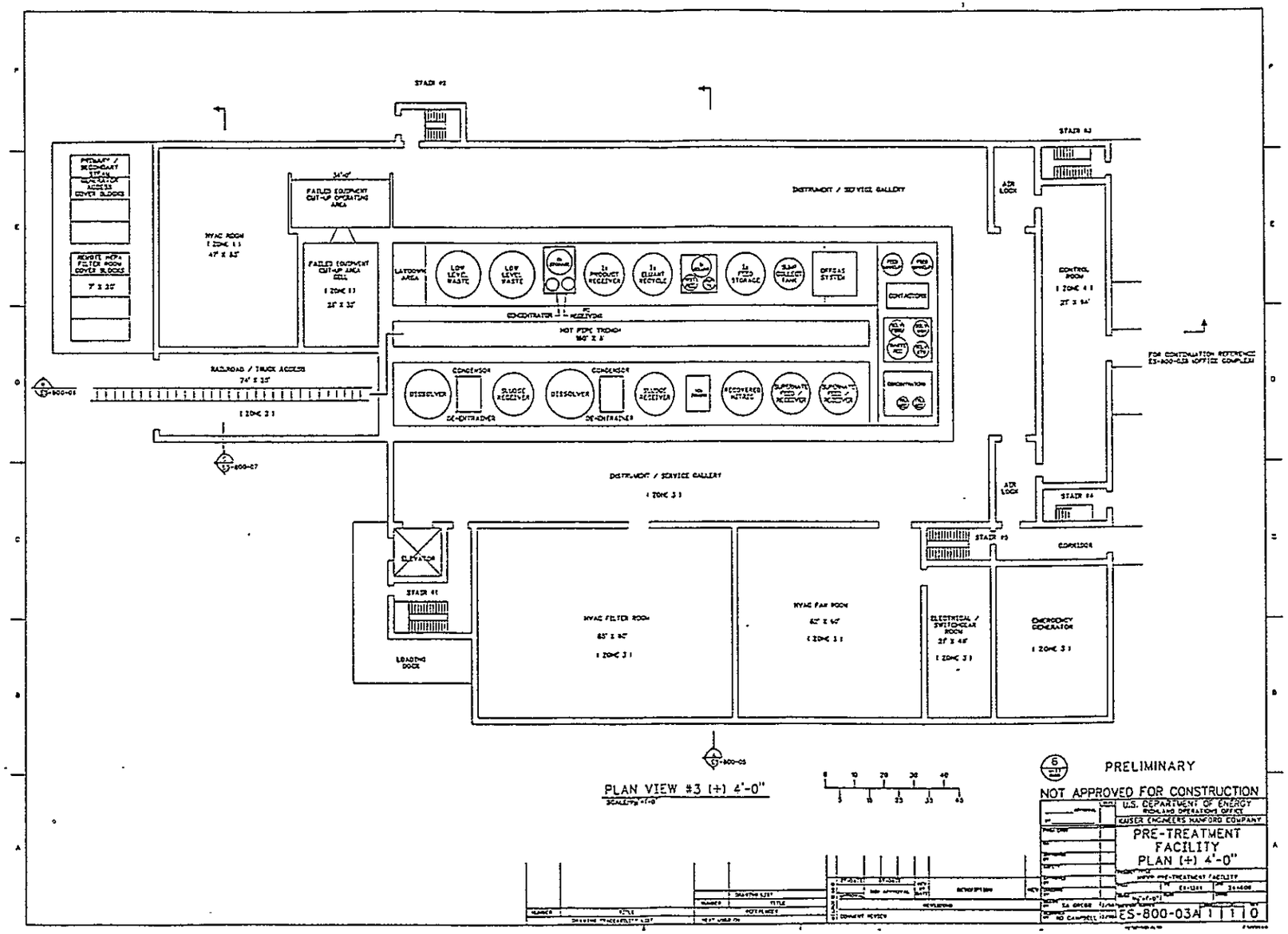

Figure E-6. Pretreatment Facility Plan (+) 4'-0". (Sheet 3 of 8)

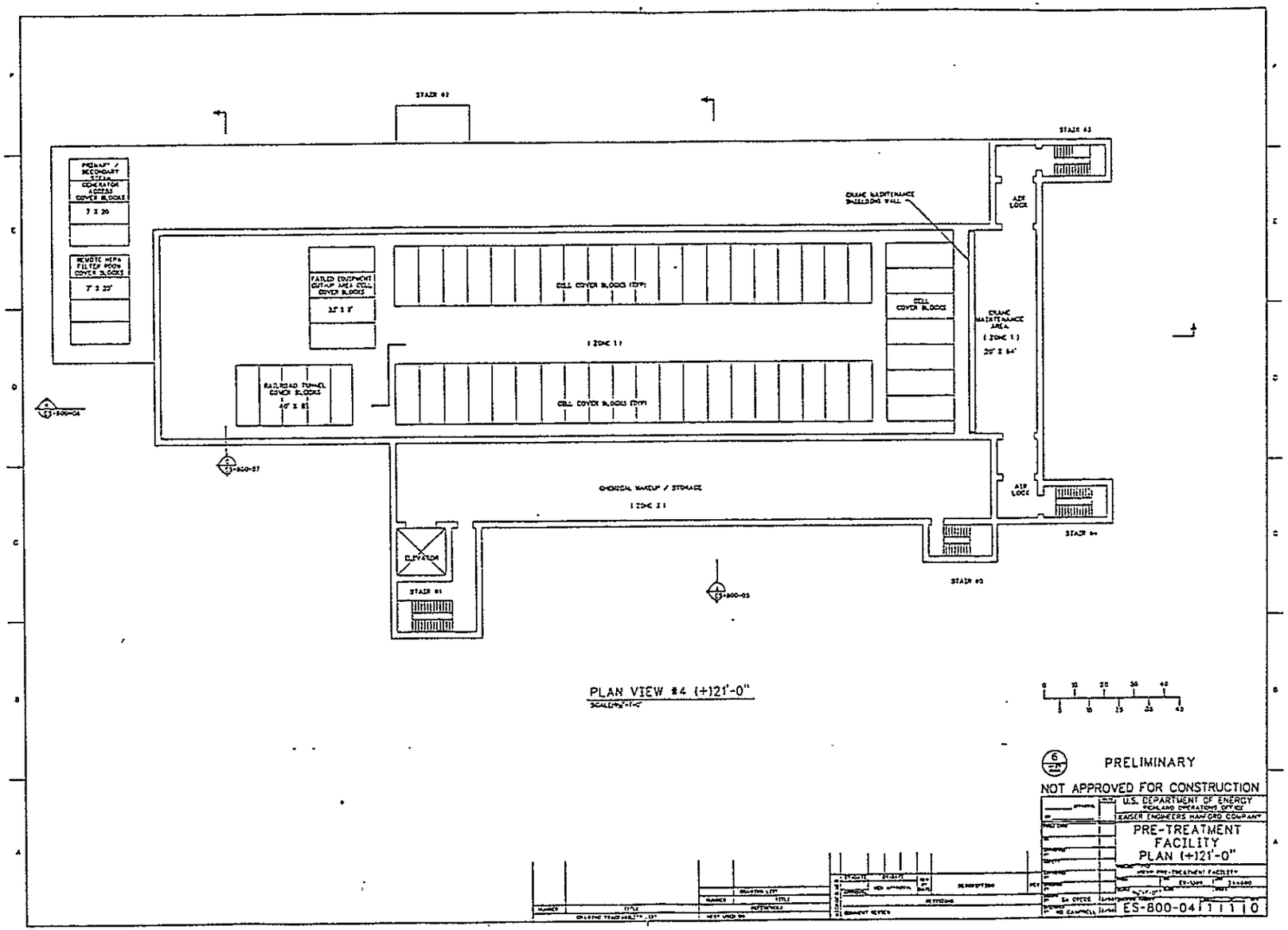

Figure E-6.. Pretreatment Facility Plan (+)21'-0". (Sheet 4 of 8)

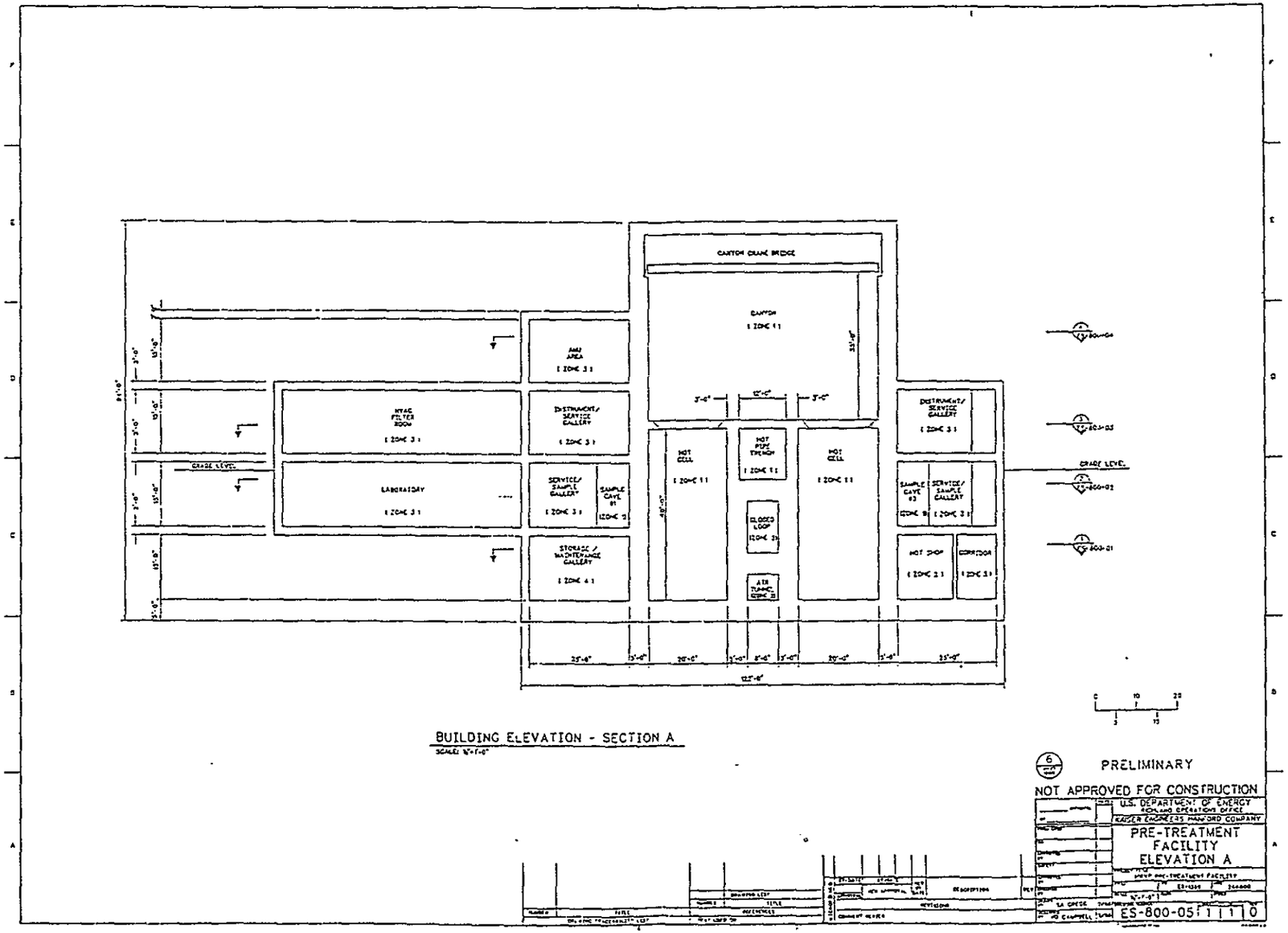

Figure E-6. Pretreatment Facility Elevation A. (Sheet 5 of 8)

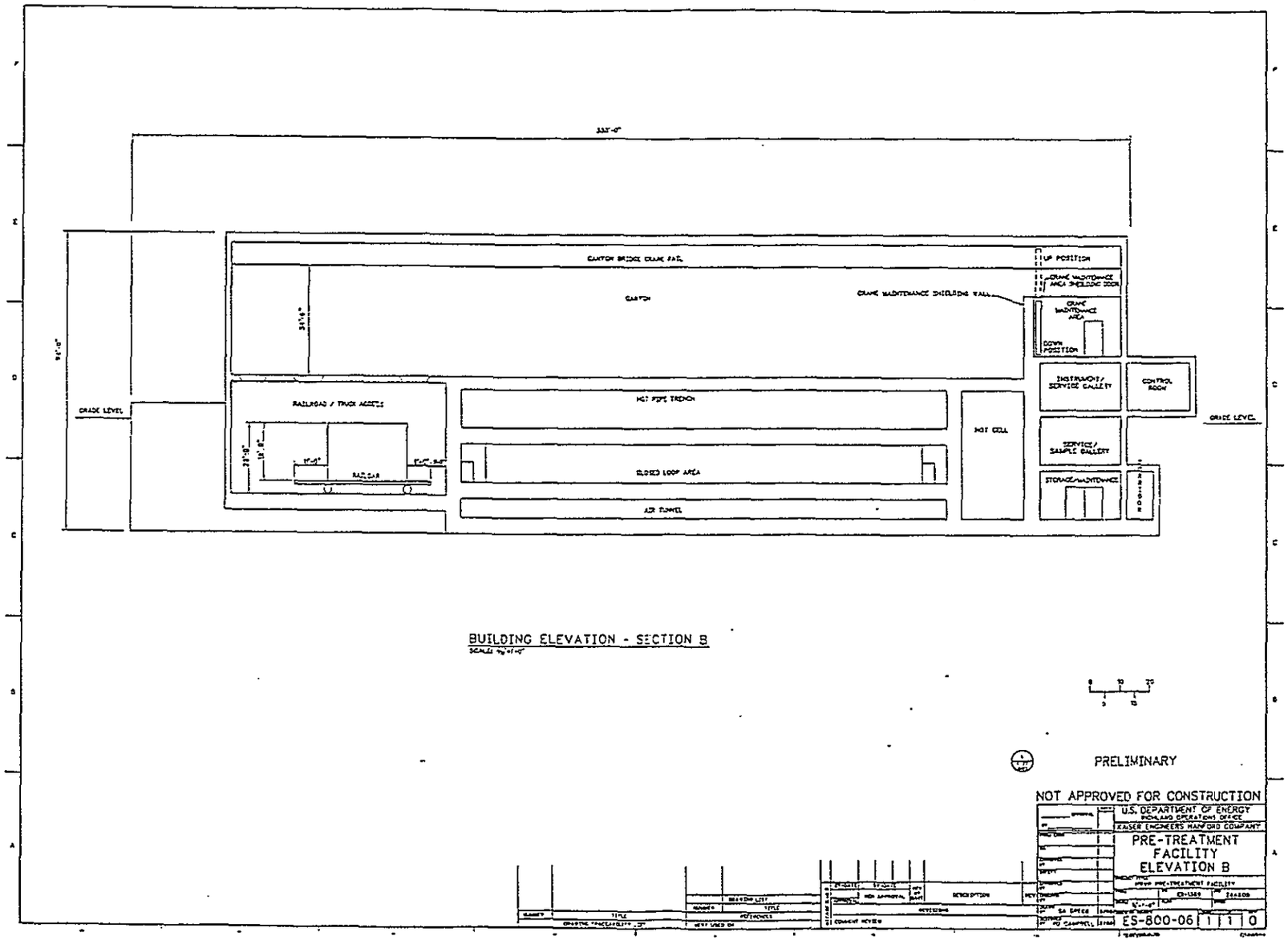

Figure E-6. Pretreatment Facility Elevation B. (Sheet 6 of 8)

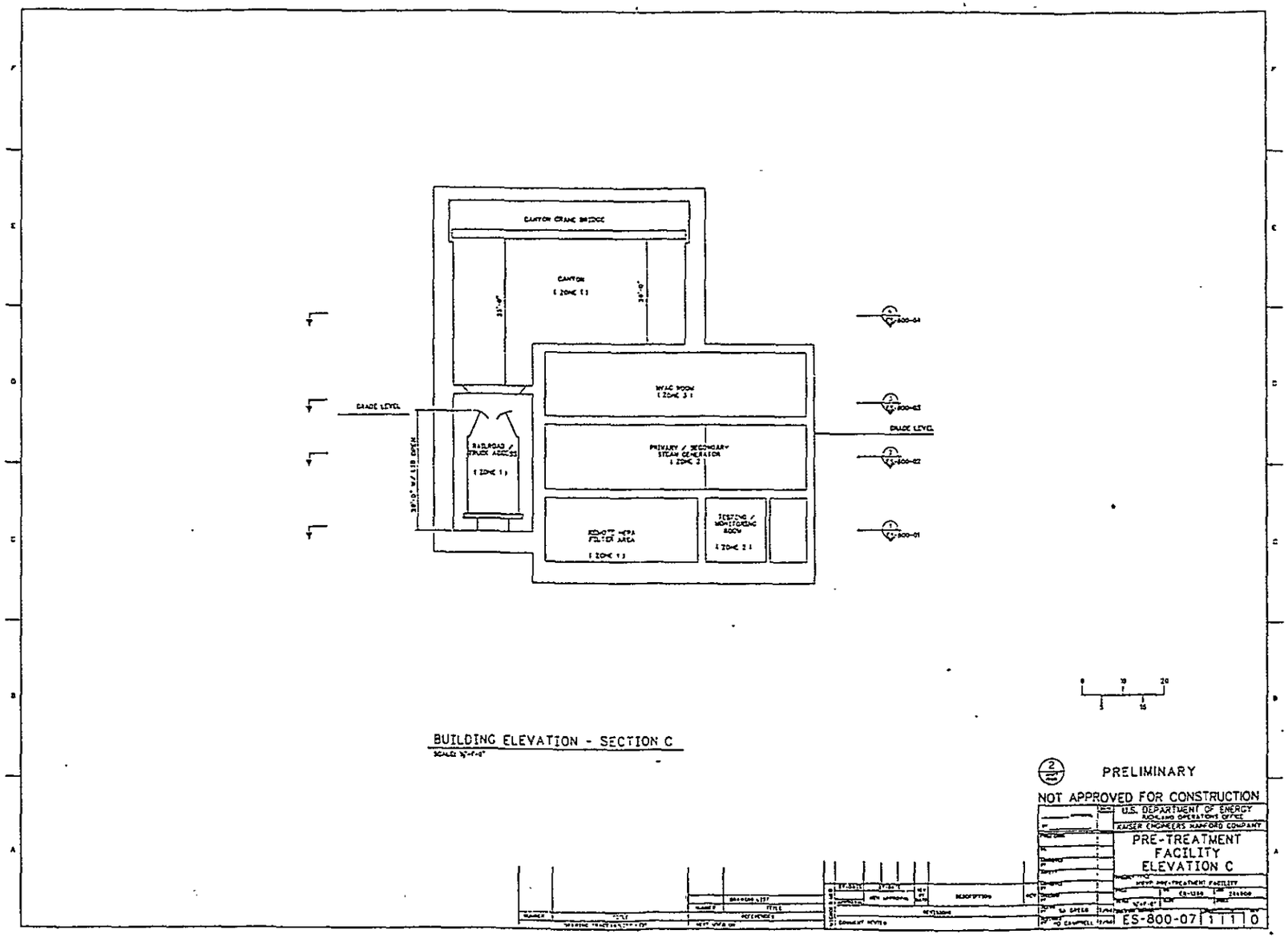

Figure E-6. Pretreatment Facility Elevation C. (Sheet 7 of 8)

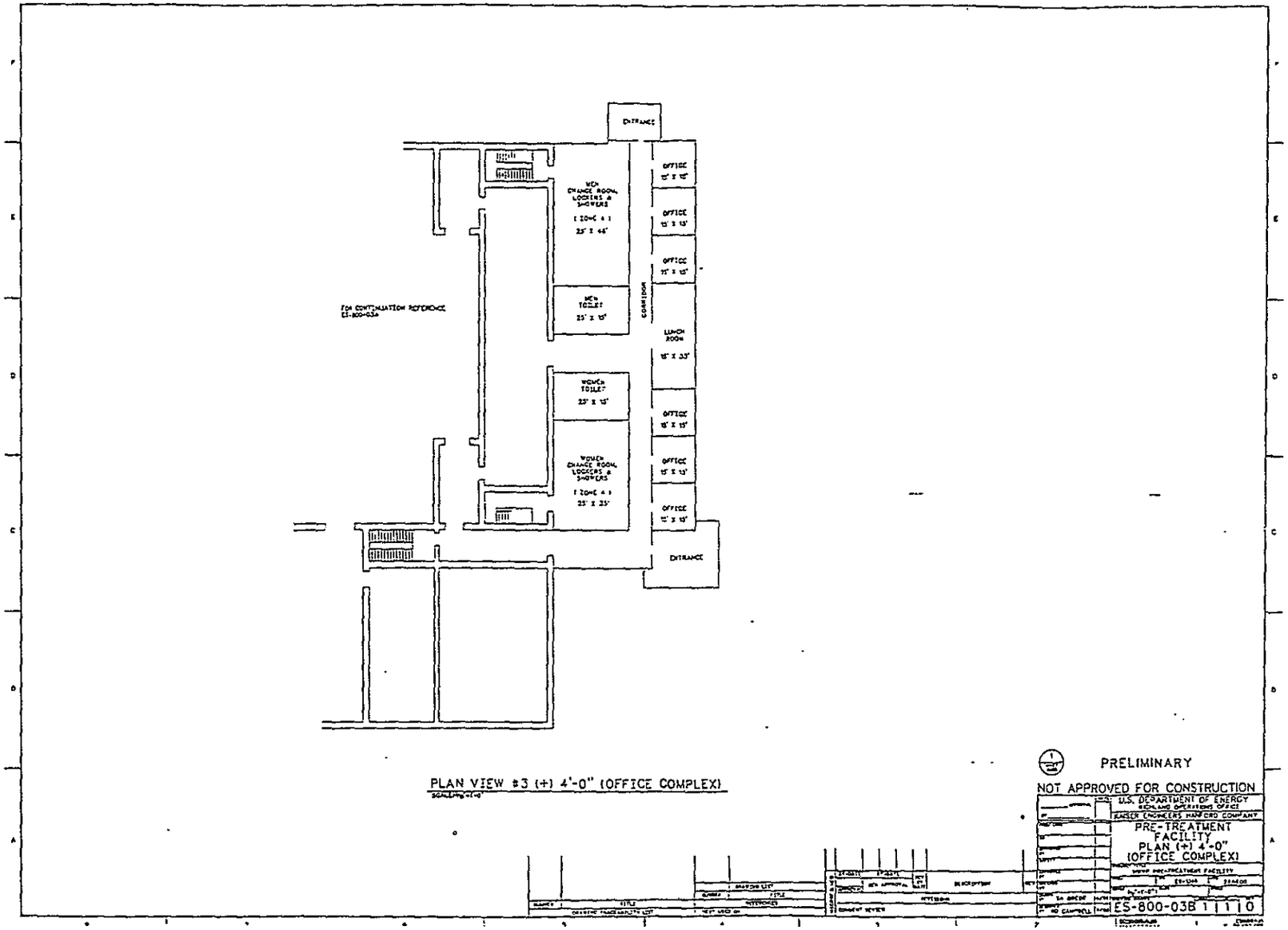

Figure E-6. Pretreatment Facility Plan (+) 4'-0". (Office Complex) (Sheet 8 of 8)

APPENDIX F

COST ESTIMATE FOR IMPLEMENTING THE TRANSURANIC EXTRACTION PROCESS AT B PLANT

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APPENDIX F

COST ESTIMATE FOR IMPLEMENTING THE TRANSURANIC EXTRACTION PROCESS AT B PLANT

This appendix provides the basis for estimating the costs for implementing the TRUEX process in B Plant. The estimate is based on allotting five cells for TRUEX process equipment and four cells for dissolution equipment. Figure F-1 shows the proposed cell modifications required to support a 45 kg/h Hanford Waste Vitrification Plant melter. The TRUEX process equipment to be contained in five process cells includes the following:

- 5 centrifugal contactors
- 1 concentrator stripping tower
- 1 condensor
- 2 TRU receiving tanks
- 1 condensate receiving tank
- 2 solvent wash solution and solvent storage tanks
- 1 ion exchange column
- 1 ion exchange regeneration waste tank
- 2 strip receiver and sump collection tanks
- 4 pump tanks
- 1 feed makeup tank

- 1 extraction waste receiver tank
- Numerous minor equipment items, jumpers, and valves.

The four cells devoted to sludge dissolution and complexant destruction will include the following equipment:

- 2 NOx bottle cap columns
- 1 acid collection tank
- 3 sludge dissolver tanks with agitators and filters
- 3 reflux condensors
- 3 dissolver transfer pumps
- 3 precoat tanks and mixer pumps
- 3 solids collection tanks
- Numerous minor equipment items, jumpers, and valves.

The cost breakdown for modifying B-Plant to include dissolution and the TRUEX process in support of the 45 kg/h melter is given in Table F-1. The total cost is estimated to be $67 million in FY 1988 dollars. The table also provides the estimate for increasing the capacity of the pretreatment process to support the 100 kg/h melter. Since dissolution and complexant destruction are the rate limiting steps in pretreatment of the waste, the cost for increasing the pretreatment capacity was based on approximately doubling the space and equipment requirements for dissolution and complexant destruction. With these changes, the cost of $67 million increases to approximately $100 million FY 1988 dollars.

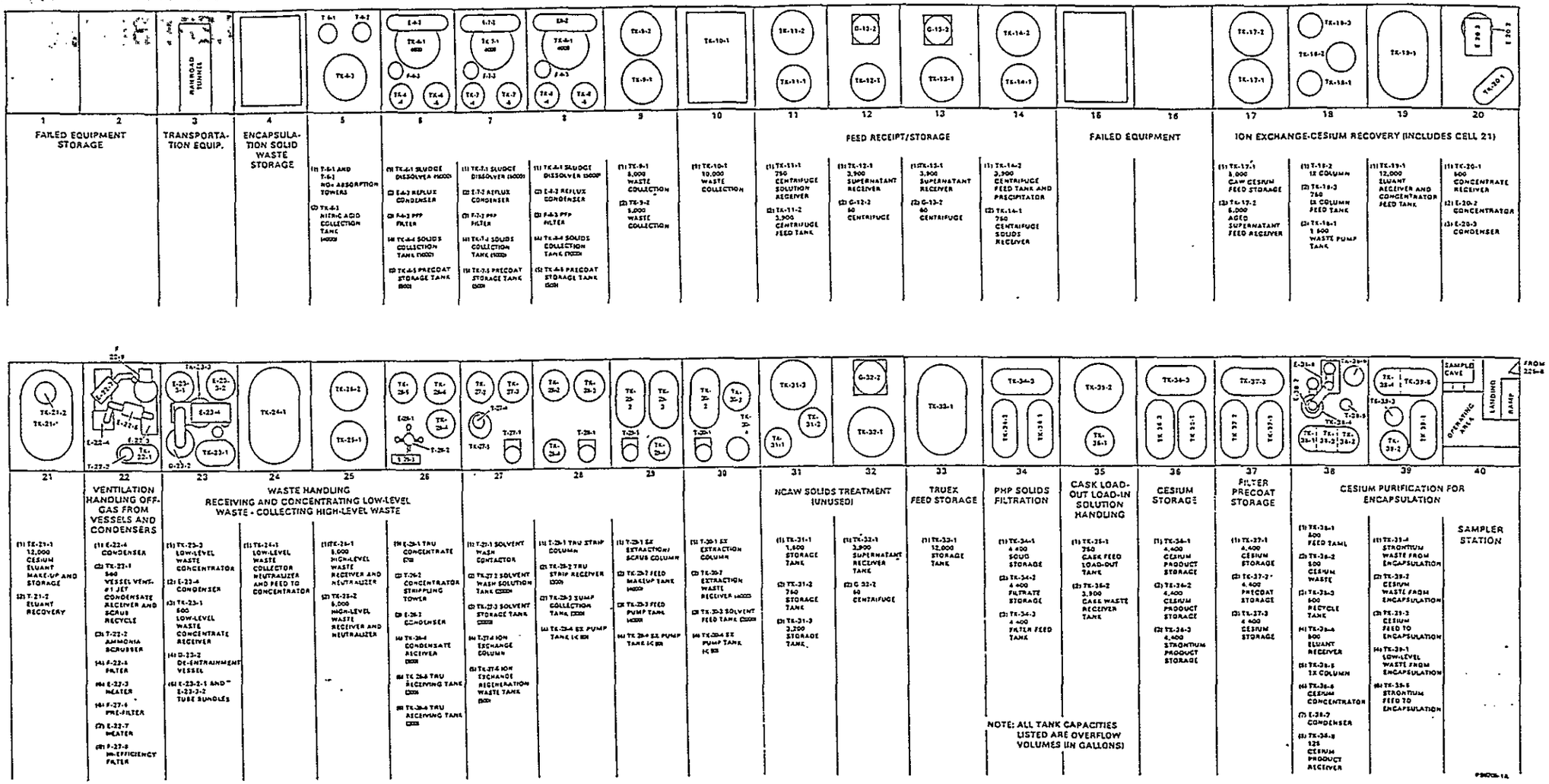

Figure F-1. Conceptual B Plant Pretreatment Facility Layout.

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Table F-1. B Plant Modifications - Transuranic Extraction Process for Double-Shell Tank Wastes.

	Sludge dissolution PHP filtration ($M)	Complexant destruction storage system ($M)	TRUEX ($M)	Total ($M)
Equipment, jumpers, valves, and specials	9.1	-	9.1	18.2
Cold side piping elect. and instr.	1.4	3.7	3.5	8.6
Removal and disposal of existing equip cell mods	2.8	-	3.5	6.3
A/E design inspections constr. mgmt., project mgmt.	7.3	1.9	8.9	18.1
Escalation-excluded	0	0	0	0
Contingency 30%	6.5	1.7	7.6	15.8
Total to support 45 kg/h melter	27.1	7.3	32.6	67.0
Increased dissolution and complexant destruction capacity				34.4
Total to support 100 kg/h melter				~100

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APPENDIX G

B PLANT COMPLIANCE TO DOE ORDERS, SEISMIC RESISTANCE, AND ENVIRONMENTAL REGULATIONS

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APPENDIX G

B PLANT COMPLIANCE TO DOE ORDERS, SEISMIC RESISTANCE, AND ENVIRONMENTAL REGULATIONS

Because of the age of the B Plant facility, an evaluation of the facility to meet DOE orders, seismic restrictions, and State and Federal environmental laws is necessary. The evaluations provided in this appendix conclude that significant cost and schedule impacts would most likely be incurred if B Plant is used beyond double-shell tank (DST) processing and potentially for the processing of DST wastes after the year 2000. These impacts are due to increasing the degree of compliance with DOE Order 6430.1A.* This appendix also concludes that further seismic evaluations are needed in the FY 1989 Safety Analysis Report (SAR) for B Plant. The update of the seismic analysis from previous analyses will determine the combined effects of a lower source term and more stringent criteria. The evaluation is expected to show increased seismic resistance of the B Plant Canyon and support facilities. An evaluation of the facility's compliance with State and Federal environmental laws shows that projects are currently underway to ensure that liquid effluents sent to B Pond meet regulatory requirements. All other facility upgrades are being addressed in preparation for pretreating Neutralized Current Acid Waste (NCAW).

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*An assessment of the viability of B PLant to perform the waste management mission was summarized in "Assessment of Double-Shell Tank Waste Pretreatment Options," (WHC-SP-0464, Westinghouse Hanford Company, Richland, Washington, March 1989), subsequent to preparation of this report. The areas investigated included (1) an evaluation of compliance with DOE, Washington State, and federal regulations; (2) a preliminary accident analysis; (3) a natural forces evaluation to determine the facility structural response to a seismic event; and (4) a life-extension analysis to examine the facility for aging effects. No issues were found that would permit B Plant from completing the pretreatment mission. The viability evaluations identified an additional $14 million in upgrades required to bring the facility to a condition that complies with DOE design criteria, safety, and environmental orders.

G.1.0 B PLANT COMPLIANCE WITH DOE 6430.1A

G.1.1 INTRODUCTION

Plant features were assessed for compliance with the December 25, 1987 draft of DOE Order 6430.1A. The U.S. Department of Energy-Richland Operations (DOE-RL) is responsible to determine the extent of compliance required on existing facilities. In general, upgrades will be designed under the new criteria but wholesale changes to bring existing facilities into compliance are not required or anticipated.

G.1.2 METHOD OF EVALUATION

The review was premised on full compliance to identify all the potential cost impacts. The safety class systems listed below are assumed to require full compliance in order to bracket the upper bound costs.

G.1.3 SAFETY CLASS SYSTEMS

Figure G-1 depicts the requirements and implications for "Safety Class" systems described in DOE Order 6430.1A. The safety class criteria represent the most significant change in criteria since construction of the prior generation of facilities such as B Plant. The existing B Plant SAR (SD-WM-SAR-013 Rev. 0, July 1985, Section 2.3) concludes that no credible accident would result in a violation of offsite release limits. Hence, from the standpoint of environmental release, B Plant may not have many safety class systems. Specific safety class items are required in other portions of

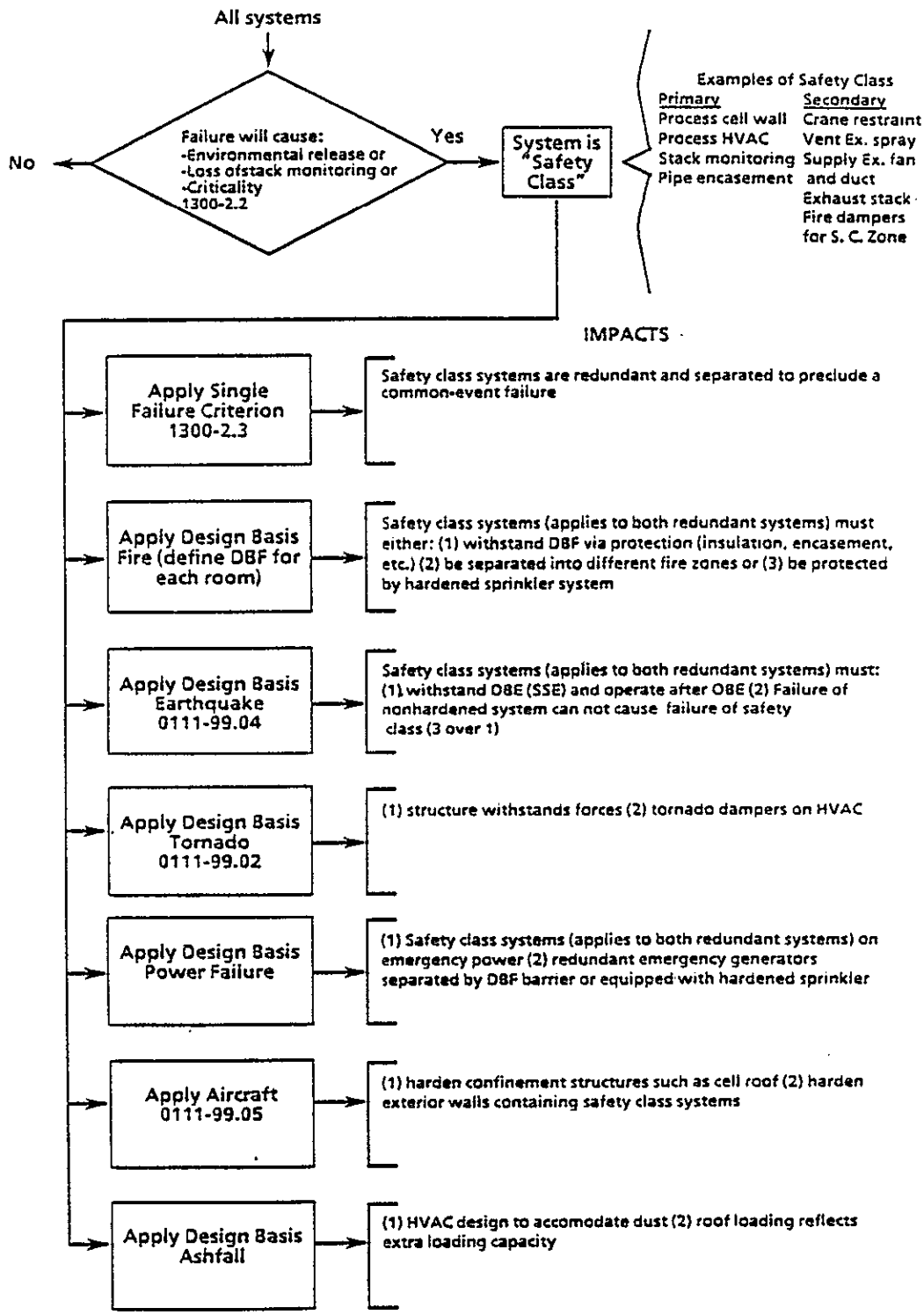

Figure G-1. Assessment of DOE Order 6430.1A Safety Class Systems.

the criteria which are not negotiable or tied to an analysis. They are as follows:

Safe Class System	Reference in 6430.1A
• Zone I Confinement System (including HVAC and Structure)	1300-7.2, 1530-99.0, 1323-5.2
• Stack Monitoring	1300-7.2
• Instrumentation	
- To achieve and maintain safe shutdown	1300-7.2
- Monitor HVAC Zone differential	1660-99.0.2
- Supporting Safety Class	1300-7.2
- For fire protection of other safety class systems	1660-99.0.2
• Control Rooms or Areas occupied during and after Design Basis Accident (DBA) conditions (HVAC, Instrumentation)	1600-99.0.7
• Fire Protection System supporting above safety class	1530-99.0

The operation of these safety class systems through the design basis accidents listed in Figure G-1 implies seismic and tornado hardening, hardened emergency power, redundant components (fans), redundant power supplies, redundant control circuits, and hardened fire protection.

G.1.4 COSTS

Table G-1 lists the actions necessary to bring B Plant into a maximum degree of compliance with DOE Order 6430.1A. The costs shown are rough estimates obtained through discussion with cognizant personnel. Design media does not exist to support the costs since none of the actions have been studied in any detail.

Table G-1. Summary of B Plant Compliance Impacts (6430.1A).

Criteria section	Action	Cost (M)
0111-99.0.4	Upgrade Building Shell for Seismic	50
1300-1.3	Reduces Process Sampling to ALARA	0.5
1300-1.3	Hardened Emergency Generator	1
1300-5.5.1	Radiation Monitoring on UPS	0.1
1300-6.1	Line 20 Additional Cells	20
1300-6.2	Redundant Power to HVAC Fans	1
1300-6.2	Seismic Upgrade Zone I Fans, Duct & Stack	10
1300-8	Hardened Liquid Effluent Monitoring	1
1323.4.4	Closed Loop Cooling/Heating for Process	30
1530-8.3.4	Add Smoke Detectors	0.2
1530-9	Dedicated Fire Water Storage for CAT I Sprinklers	0.5
1530-99	Separation of Redundant Safety Class Systems	10
1530-99	Hardened Fire Protection for Safety Class Systems	10
1530-99	Fire Protection for Operating Galleries	2
1530-99	Redundant Fire Detection for Process Confinement	0.2
1540-99.0.1	Post DBA Cooling and Heating Water for S.C.	0.5
1540-99.0.1	Hardened Water Supply	0.5
1540-99.0.1	Two Sources of Motive Power for Cooling Water	0.1
1550-99.0.2	Hardened Supply Air to Control Room/Gallery	5
1660-99.0.2	S.C. Instrumentation is DBA Resistant and Redundant	5
1660-99.0.4	Redundant Instrumentation is Separated or Protected	5
1660-99.0.4	Hardened Control Areas/Rooms	5
		160M
	Use 100M - 250M	

G.1.5 CONCLUSION

B Plant compliance with DOE Order 6430.1A is determined on the basis of engineering judgement and technical justification. Operation of B Plant for a 6 yr DST mission would not warrant incorporation of new requirements. However, a longer term mission for a facility built in 1945 should include upgrades to meet modern criteria commensurate with a new facility. The cost of these upgrades would fall in the $100 M to $250 M range and the schedule outage for construction would be 3 to 5 yr. Missions beyond DST processing should definitely address these cost and schedule impacts and be compared to construction of a new facility.

G.2.0 UNCERTAINTIES RELATED TO B PLANT SEISMIC RESISTANCE

One structural evaluation of the T Plant and B Plant canyons was conducted by URS/Blume in 1974. Four analyses have been conducted by J. A. Blume between 1974 and 1981 for PUREX which is a canyon facility similar to B Plant. These analyses were premised on yielding of the reinforcing steel rather than the concrete.

At B Plant, the reinforcing steel was predicted to yield at a 0.017 g earthquake (.25 g/15). At PUREX, the reinforcing steel was predicted to yield at a 0.04 g earthquake (.25 g/6.27). Further PUREX evaluations predicted that rebar yielding limits would be reached at a 0.15 g earthquake. The Safe Shutdown Earthquake (SSE) is .25 g and would result in stresses 15 times the rebar tensile strength at B Plant. The margin between damage to the rebar and total collapse is unknown.

A second method of analysis planned for this fiscal year is premised on the tensile strength of the concrete rather than the rebar. Rebar densities in the 200 Area canyon buildings (including B Plant) are low, suggesting that

the initial studies premised on rebar strength, may be too conservative. Preliminary Westinghouse Hanford Company (WHC) studies indicate the SSE would overstress the concrete by a factor of 1.5 to 3. This compares to rebar overstress factor of 15 for B Plant in prior analyses.

It is anticipated that the existing structures can be shown to withstand a substantially larger earthquake than previously concluded. The capability to withstand the SSE is not known, but it may be possible to show that the structures, while incurring major structural damage, could survive the SSE without collapsing.

The following can be concluded on the seismic issue is:

1. Previous safety evaluations of B Plant have concluded that radiation releases as a result of the collapse of the B Plant Canyon were within acceptable risk guidelines of that time (consequences as presented would exceed present guidelines however). The source term for the pretreatment mission is lower as shown in the table below. The net effect of more stringent criteria and a lower source term will be quantified in the next revision to the B Plant SAR to be conducted in FY 1989.

	Present SAR "CAW"	Future SAR "NCAW"
^{90}Sr in feed	44.5 Ci/gal	13.9 Ci/gal
^{137}Cs in feed	49.5 Ci/gal	11.8 Ci/gal
Cell 27 Organic	1 Ci/gal ^{137}Cs	10^{-3} Ci/gal ^{241}Am

2. Further evaluations are proposed that are expected to show increased seismic resistance of the B Plant Canyon and support facilities.

3. Construction of a new facility would offer assurance against an SSE induced collapse that cannot be fully guaranteed for B Plant.

G.2.1 REFERENCE

Letter, 1987, "Assessment of Past Seismic Evaluation of 200 Area Canyon Facilities," (SA:GRW: 87-171, Structural Analysis to R. M. Marusich, October 22, 1987).

G.3.0 STATE AND FEDERAL ENVIRONMENTAL LAWS

Consultants have been employed between August 1987 and April 1988 to review B Plant for compliance with the following laws:

- Resource Conservation and Recovery Act (RCRA)
- Clean Water Act (CWA)
- Clean Air Act (CAA)
- Toxic Substances Control Act (TSCA)
- Federal Insecticide, Fungicide and Rodenticide Act (FIFRA)
- Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)
- Safe Drinking Water Act (SDWA).

The assessments show B Plant fundamentally in compliance with requirements for removal of nonradioactive dangerous waste from the plant in containers and for air emissions. Areas of noncompliance were largely procedural and administrative. Liquid discharges to the soil represent significant area for upgrade. The streams at issue are:

Stream	Discharged Via
Chemical Sewer	216-B-63 Trench
Steam and Process Condensate	216-B-55,-62 Cribs
Cooling Water Discharge	B Pond

Several NCAW pretreatment upgrade projects are intended to address these streams:

W-007 B Plant Process Condensate Treatment Facility $14.7 M, FY 1990 LI (provides reverse osmosis/ion exchange treatment of BPC condensate)

W-010 B Plant Environmental Compliance Upgrades $3.5 M, FY 1990 LI (in combination with W-004, protects chemical sewer from spills/drainage of toxic chemicals used for process makeup)

W-004 B Plant AMU Environmental Upgrade $1.05 M, FY 1989 GPP (protects chemical sewer from 3rd floor AMU spills and drainage)

W-008 B Plant Chemical Sewer Neutralization System $1.0 M, FY 1988 GPP (provides collection sampling and neutralization for chemical sewer)

Completion of these projects will provide engineered barriers and instrumentation to ensure the liquid effluents sent to B Pond from B Plant will meet regulatory requirements. Due to existing contamination in B Pond, a motive exists to replace or upgrade the pond to prevent further spread of contamination through the soil to the ground water.

In summary, B Pond replacement appears to be the only outstanding issue currently identified that could require significant additional funding to comply with state regulations. B Pond replacement costs should not exceed 10 M if such a project is needed. It does not appear that these environmental laws would prohibit sending water (within acceptable toxicity limits) to a pond.

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Westinghouse Hanford Company (continued)				
O. E. Place	S6-70C	X		
I. E. Reep	S6-65	X		
C. R. Reichmuth	R1-19	X		
H. H. Rode	R3-48	X		
R. A. Smith	B2-04	X		
D. A. Turner	R1-10	X		
J. E. Van Beek	R1-48	X		
D. J. Washenfelder	R1-43	X		
F. T. Weber	B2-10	X		
D. Wodrich	R2-23	X		
J. C. Womack	R2-18	X		
G. D. Wright	B2-06	X		
Central Files (2)	L8-04	X		
Documentation Services (4)	L8-15	X		
Publications Services (2)	R1-08	X		